WATER WORKS AND SEWERAGE

October, 1934 — Editor — Vol. LXXXI. No. 10

Aeration Tanks of the Self-Liquidating Sewage Treatment Works of Herington, Kan. (Designed by Black & Veach, Engineers, Kansas City, Mo.; Financed as a Utility by the Reconstruction Finance Corporation)

IN THIS ISSUE

Chlorination of Sewage
Cannery Waste Treatment in Wisconsin
A Study of Filtering Materials for Rapid Sand Filters
What Reclamation of Sewage Means to Herington, Kan.
Report of Meeting of New England Water Works Association

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Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues

Reeves J. Newsom, President, Community Water Service Corporation, New York City, will recount experiences gained in "Thawing of Mains and Service Pipes" outlining the most successful methods and equipment developed in this important emergency operation during the past winter.

Richard Gould, Chief Engineer, Department of Sanitation, New York City, will describe New York City's 50 million gallon sewage treatment project under way which involves the use of chemical precipitation processes and mechanical sludge dewatering.

Herman Forster, Deputy Commissioner of Water, New York City, will discuss the "Recreational Usage of Reservoirs" and the Department of Water Supply's system of sanitation control and procedures followed in regulating recreational usage of its reservoirs and lands bordering on them.

C. E. Keefer, Engineer of Sewage Treatment, Baltimore, Md., will discuss sludge dewatering operations at Baltimore. Ordinary sand bed operation vs. vacuum filtration vs. the elutriation filtration process, recently developed at Baltimore, will be compared and cost data presented.

W. L. Eisert, Division Manager, Northeastern Water and Electric Service Corporation, relates and discusses methods found successful in building good will and better public relations for his company.

Dr. W. Rudolfs, Chief of Water and Sewage Research, New Jersey Agricultural Experimental Station, Rutgers, N. J., will report on basic studies of the mechanics of the activated sludge process—including the effect of varying degrees of chlorination.

Geo. C. Hodges and J. Walter Ackerman of the Utica (N. Y.) Consolidated Water Company will report on the effectiveness of chlorine-ammonia treatment in checking tuberculation of a water main, thereby increasing its capacity and reducing frictional head losses in an important supply conduit.

A. M. Rawn, Assistant Chief Engineer, Los Angeles County Sanitation Districts, will describe a new development in sewer construction—involving the use of 6 ft. lengths of 36 in. vitrified piping with cement bells.

John H. Murdoch, Jr., Uniontown Water Company, Washington, Pa. (Chairman Finance Division A.W.W.A.), will discuss "Present Trends in Public Utility Rate Making and Financing."

M. W. Tatlock, Superintendent, Sewage Treatment, Dayton, O., will describe recent improvements in fertilizer production facilities at the Dayton plant and relate the successful marketing of pulverized digested sludge at a worthwhile profit.

Dr. A. J. Fischer, Development Engineer, The Door Company, will report on some of the newer developments and unusual features of European Plants, observed by him on a recent tour of foreign countries.

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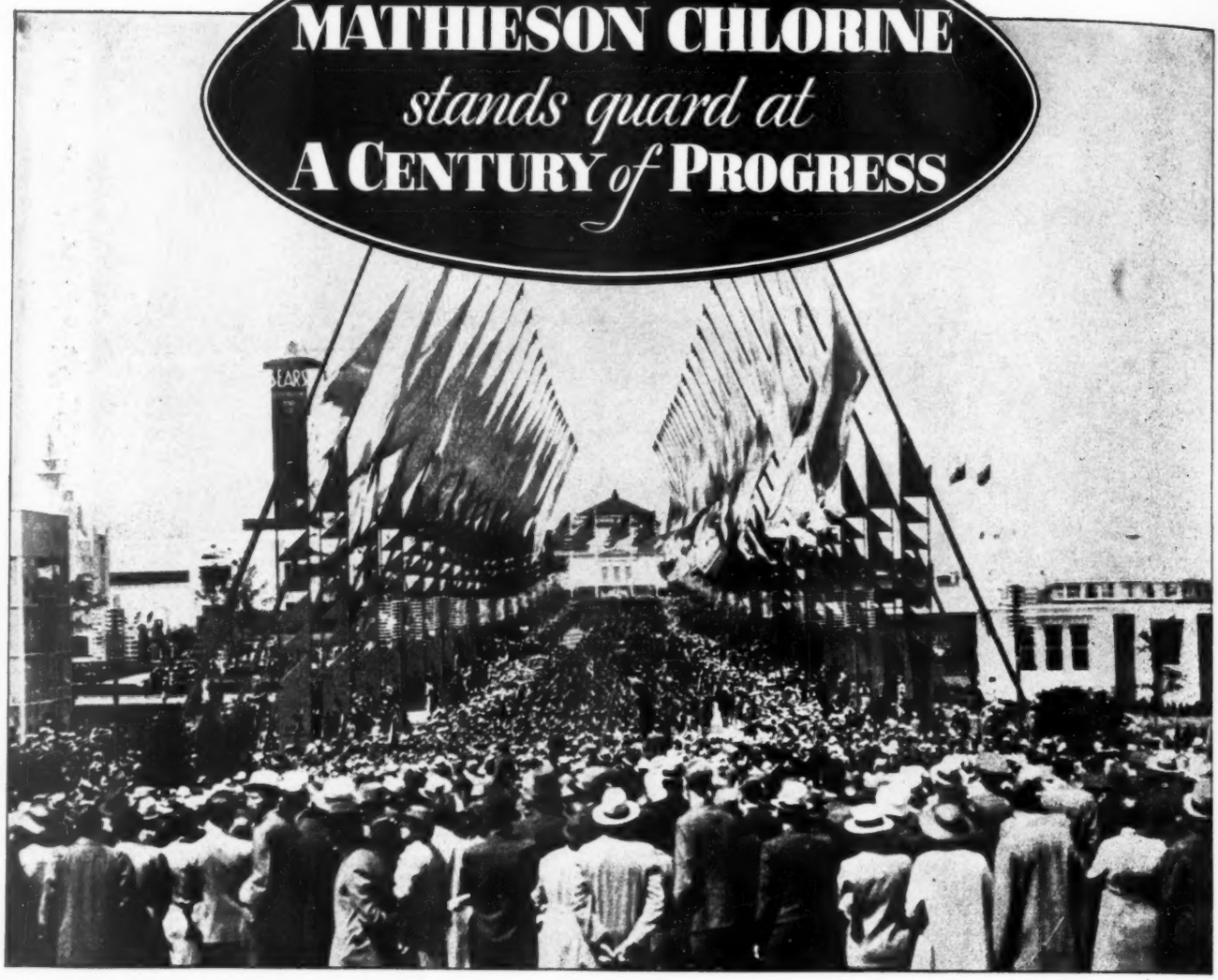

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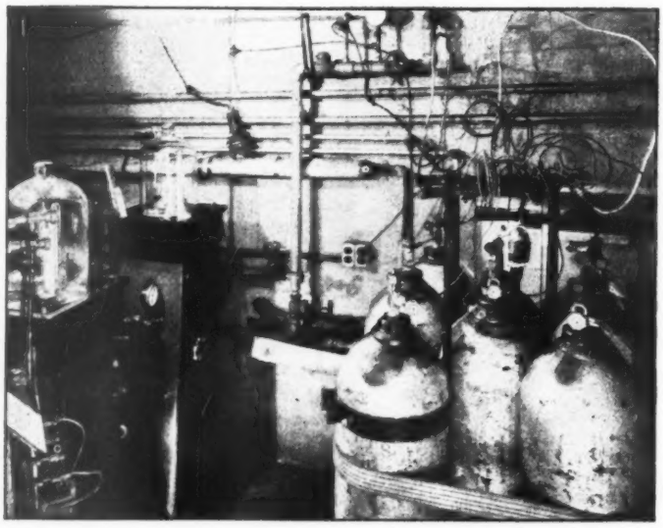

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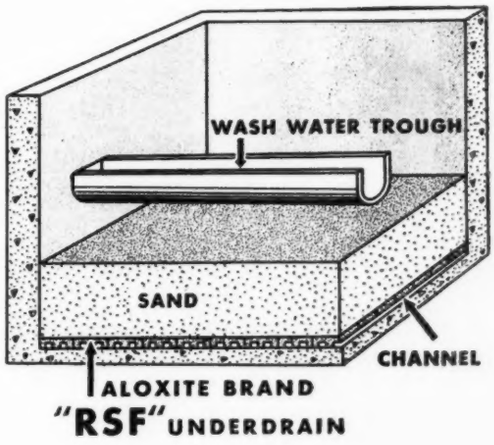

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William R. Kenny
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III—Buffer Action
IV—Determination of pH
V—Sources of Error

Section B. PRACTICAL APPLICATION OF HYDROGEN ION DETERMINATIONS IN INDUSTRY AND SCIENCE

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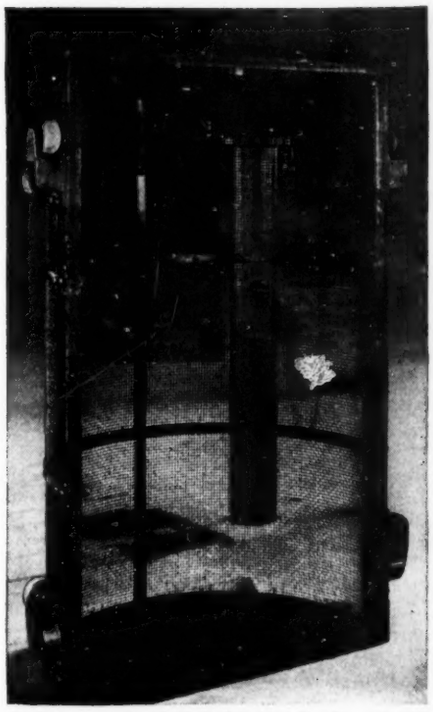

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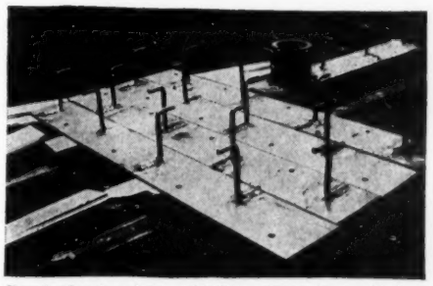

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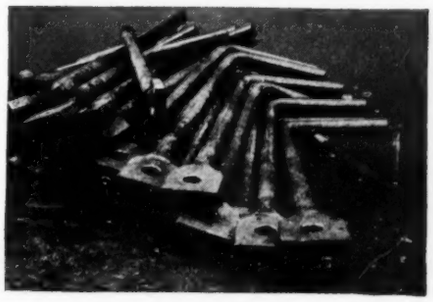

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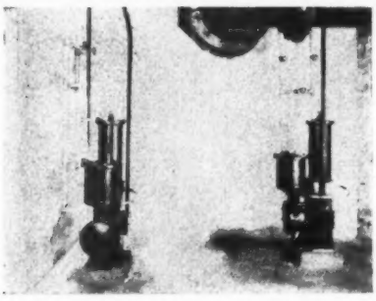

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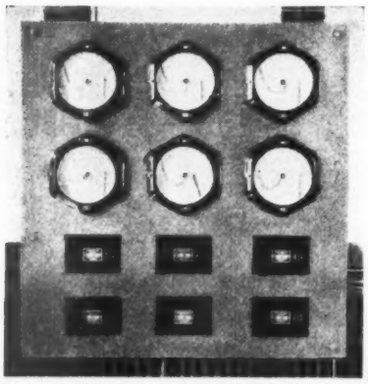

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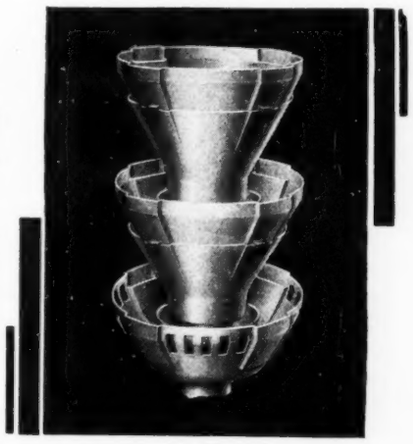

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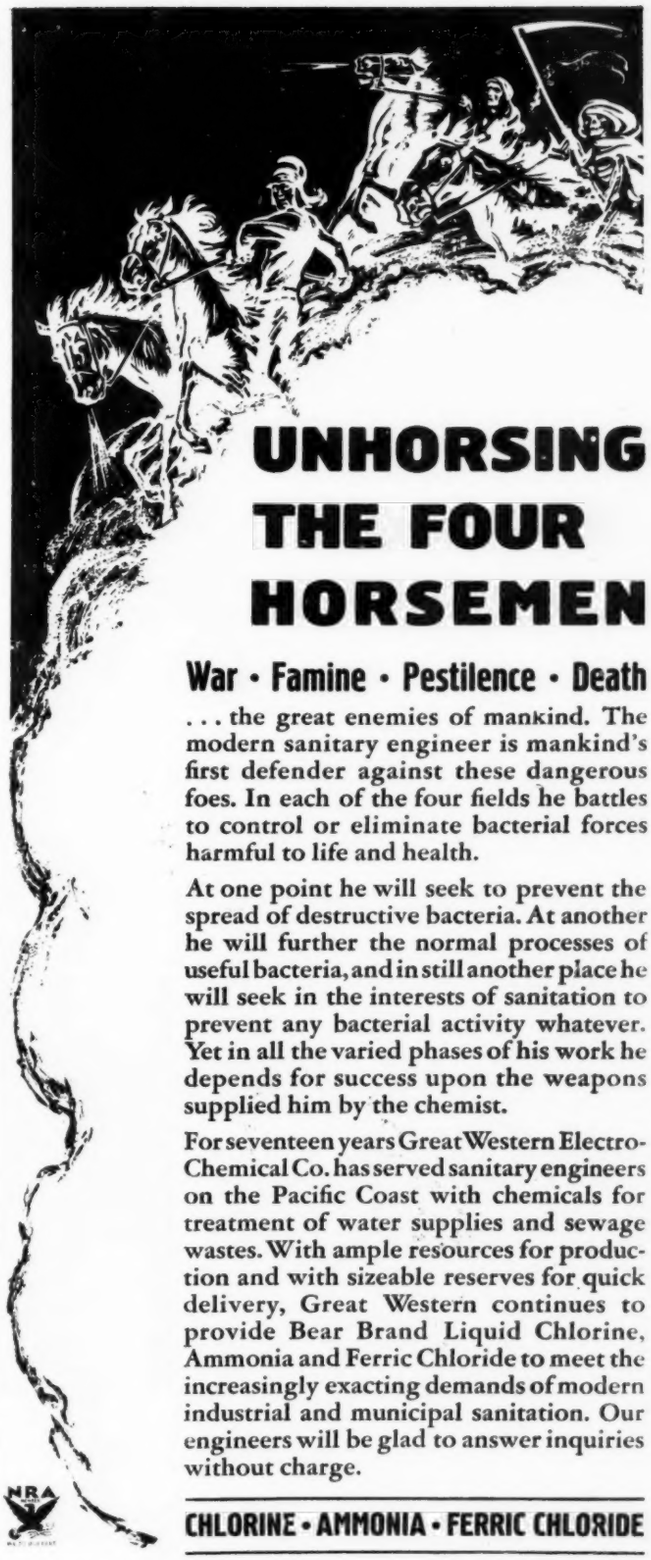
INTERNATIONAL



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VOL. LXXXI OCTOBER, 1934 No. 10

Aeration Tanks Equipped with Aloxite Tubular Diffusers. Beyond Is the Primary Clarifier; Crude Sewage Screening and Pump Station; Digester in Left Background.

WHAT RECLAMATION OF SEWAGE MEANS TO HERINGTON, KANSAS

By J. E. WHITE[1] and F. M. VEATCH[2]

THE reclamation of municipal sewage for use as an industrial water supply has been practiced successfully by the city of Herington, Kansas, since December 13, 1933, when the newly completed sewage disposal works was put into operation. The effluent from the sewage treatment plant is pumped by the city to a storage tank located at the shops of the Rock Island Railroad, where it is sold to this company for use as its boiler water supply in its shops and locomotives.

J. E. White

This development was especially timely; for, during the past summer its merit as a water conservation project as well as a sanitation measure was in marked evidence. The railroad company would have experienced a serious shortage during the recent drought period if the city sewage had not been available for use. As a sanitation project the novel feature is found in the sale of effluent, which reduces the cost of treating the sewage to a negligible figure.

Naturally an unusual set of circumstances are necessary to make sewage reclamation by this method advisable. The disposal problem of the city must be so acute that treatment is necessary in any event, and the water requirement of the industry must be such that the quality of the treated sewage constitutes a satisfactory water supply and otherwise constitutes an economical solution of the problem of water supply.

In this particular instance the city sewage was being discharged into Lime Creek with no treatment except that provided by a septic tank built in 1910 which was entirely inadequate. The conditions along the stream were so bad that the city of Herington was ordered by the Kansas State Board of Health to construct a sewage disposal plant for complete treatment and to have it in operation on or before March 1, 1934.

The railroad company, which uses from 400,000 to 600,000 gallons of water daily for its shops and locomotives, had for a number of years derived its supply from a small impounding reservoir and from Lime Creek at a point below the outfall of the city sewer. The supply from the city reservoir direct was inadequate to supply the railroad's demand continuously, and that from Lime Creek was of inferior quality due to its hardness and the presence of sewage as well. Furthermore, its use entailed high pumping costs.

The result of this particular set of circumstances was that a contract was entered into between the railroad company and the city, whereby the city agrees to furnish water to the company for boiler use. Sewage works effluent, which under ordinary conditions amounts to 350,000 gallons per day, will be used as far as possible and the difference will be made up by untreated water from the city water supply or from other sources. The company is to pay the city for this water on a sliding rate schedule with a minimum of 5 cents per 1,000 gallons delivered to the softening tanks at the railroad shops.

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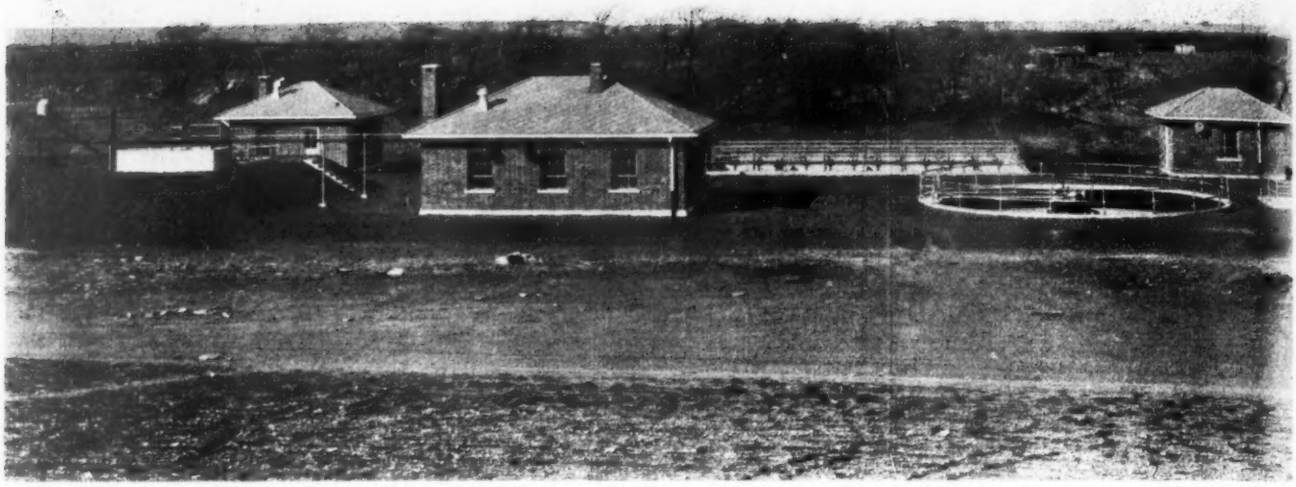
[1]Superintendent of Water and Light Dept., Herington, Kansas.
[2]With Black & Veatch, Consulting Engineers, Kansas City, Mo.



General View of Herington's Sewage Treatment Plant. Financed by R. F. C.; Self-Supporting by Income from Reclaimed Water (Effluent) Sold to Industrial User. Left to Right: Heated Sludge Digesters; Screen and Pump Station; Blower House, Laboratory and Office; Primary Clarifier (Not Visible) Is Beyond; Aeration Units; Final Center-Feed Clarifier; Effluent Pump Station.

A Self-Liquidating R.F.C. Project

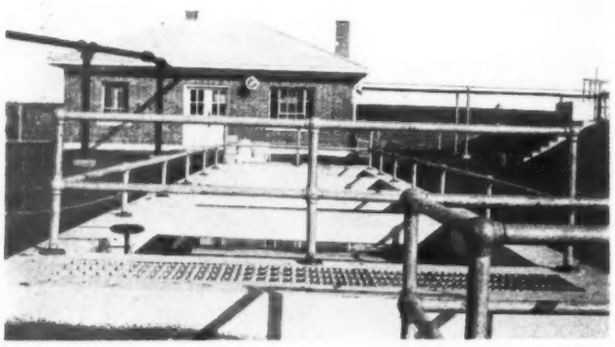
On the basis of this contract a self-liquidating loan was secured from the Reconstruction Finance Corporation to finance the project.

The sewage disposal plant is of the activated sludge type, designed to treat an average flow of 520,000 gallons per day from a population of 6,500, and includes the following units:

1. *Screen and Pump Station:*—The raw sewage is passed through a mechanically cleaned bar screen with 1 inch clear openings into a sump from which it is elevated 22 feet by means of three centrifugal pumps.

2. *Primary Settling Tank:*—Equipped with sludge removal and screen skimming equipment of the straight line type. This tank has a detention period of 1 hour and 10 minutes and an average overflow rate of 1,100 gallons per square foot of tank surface per day.

3. *Aeration Tanks:*—An aeration period of six hours with an allowance of 25% for returned sludge is provided in three aeration channels each 50 feet by 12 feet in plan and 14 feet deep. Air is supplied through porous tubes set in pairs along one side of each channel and nine feet below the water level. (See front cover illustration.)



Primary Straight-Line Settling Tank. Building in Rear Houses Blowers, Sludge Pumps, Office, Laboratory, Heating Equipment

4. *Final Settling Tank:*—The aerated sewage is settled in a circular tank equipped with sludge scrapers and arranged for central feed and peripheral overflow. This tank provides a detention period of 2 hours and 20 minutes and has an overflow rate of 540 gallons per square foot of tank surface per day.

5. *Sludge Digestion Tank:*—The raw sewage sludge and the waste activated sludge is digested in a rectangular tank which has a capacity of three cubic feet per capita. The gas from the digestion process is collected and burned under a hot water boiler and the digestion tank temperature is regulated by the circulation of hot water.

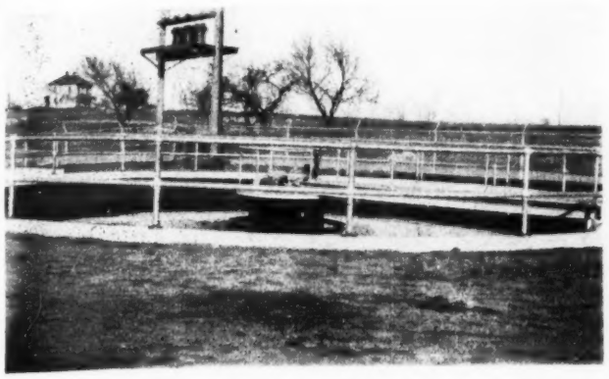
6. *Sludge Drying Area:*—An area of 20,000 square feet in four beds has been leveled off and diked for sludge drying.

7. *Office and Machinery Building:*—The air blowers, sludge pumps and other equipment is housed in a brick and concrete building in which the space for an office and laboratory is provided.

8. *Effluent Pumping Station:*—The treated sewage is collected in a wet well and pumped through a 10 inch discharge line into a 150,000 gallon elevated storage tank located at the railroad shops.

The cost of the work was as follows:

Excavation	$ 1,524.60
Raw sewage pump station with screen	7,619.00
Primary settling tank	2,900.00
Aeration tank	6,400.00
Final settling tank	5,468 00
Machinery and office building	8.205.00
Sludge digestion tank	6,000.00
Effluent pumping station	3,149.75
Yard piping	4,200.00
Force main	1,933.00
Miscellaneous items	2,835.05
Elevated storage tank	5,851.11
Total	$56,085.51



Final Clarifier, Central Feed Type, Herington, Kan.

The operation of the plant has been very satisfactory. A chemist was in charge during the period between March 1 and June 1, and an average of 27 p.p.m. B.O.D. was maintained in the effluent. Since June 1, chemical tests have not been run, but from the standpoint of appearance the effluent has been excellent.

On May 12, due to the necessity of further conserving the city's water supply, a pump was installed on Lime Creek and creek water was pumped into the effluent sump for delivery with the plant effluent to the railroad.

How Nearly the Project Is Paying Its Way

During the period between January 1 and September 1, 1934, a total of 99,016,000 gallons of sewage plant effluent and water was sold and produced a revenue of $4,950.80. The operating expense during this period was $2,094.23, as follows:

Labor	$ 703.62
Materials	146.32
Light and power	1,074.47
Miscellaneous	169.82
Total	$2,094.23

On a yearly basis this represents a revenue of $6,601.08 and an operating cost of $2,792.28. This leaves a balance of $3,808.80 to cover fixed charges, which amount to approximately $4,000.00.

There is a possibility that the project may finish its first year with a small deficit, but it must be remembered that 1934 has been an abnormal year. The protracted drought not only reduced the amount of sewage from an average of about 350,000 gallons per day to an average of only 290,000 gallons per day, but also placed the city water supply in such serious jeopardy that raw water could not be spared to supplement the sewage flow. This imposed an additional cost of pumping creek water. Power costs in the treatment process itself were also above normal because the plant was only operating at about 56 per cent of its design capacity.

As a matter of fact the operation of the project during eight months of abnormal weather and operating conditions do not give a true picture of its economy. The fact, however, that service was given under such adverse conditions and with such a small operating deficit, leaves no doubt of the feasibility of the project nor the assurance that it will be self-liquidating. It should be remembered also that the city of Herington is receiving the benefits of sewage disposal at practically no cost and that the railroad company is receiving an ample supply of water of better quality than has heretofore been available to it. Further than this, in a year of water shortage, such as the past has been, the availability of the spent water supply of the community for re-use circumvented a dilemma faced by many municipalities and industries in drought areas of the mid-west.

The operation of the plant comes under the author's direct supervision. The plant was designed and construction supervised by the co-author's firm — Black and Veatch, Consulting Engineers of Kansas City, Mo.

Heated Sludge Digesters

Courses in Public Works and Construction Offered by New York University

New York University will offer, beginning this year, a course in Public Works and Construction. Planned and arranged by Thorndike Saville, Professor of Hydraulic and Sanitary Engineering at New York University, and head of the new Water Resources Inquiry, now being conducted throughout the United States by the Department of the Interior, the course is believed to be the first of its kind in colleges of engineering or in technical schools of any kind throughout the country.

Twenty prominent engineers, public works officials, economists, and architects will be the instructors in this optional course. Each will present one special phase of present public works operations. The aim of the course is to give seniors in the engineering school and graduate engineers who may or may not be employed at the present time the technical details of bidding, letting of contracts, financing, and liquidating public works projects which are now necessary, in addition to technical knowledge and experience, for the engineer going into public works.

Among the specialists from outside the university to lecture are: Col. C. H. Birdseye, W. W. Brush, Dr. Morris L. Cooke, J. W. Follin, F. E. Green, Col. John P. Hogan, C. A. Holmquist, Dr. S. L. Land, Malcolm Pirnie, Carlton S. Proctor.

Oklahoma City Sewer Damaged by Hydrogen Sulphide

A masonry sewer carrying combined sewage (industrial wastes from the meat packing plants and domestic sewage) has shown marked deterioration in recent years. A survey, made at the instigation of the city and packing plant authorities jointly, reveals that the attack (softening and sloughing away of the masonry structures and corrosion of metal parts) is chargeable to hydrogen sulphide produced in the sewage by bacterial splitting of the mineral sulphates present. Subsequently, the accumulated sulphide gas, converted to sulphuric acid on the sewer walls above flow-line, did the damage. Both the gas production and its conversion to acid is the result of bacterial action.

NEW ENGLAND WATER WORKS ASSOCIATION HOLDS ITS 53RD ANNUAL CONVENTION

THE 53d Annual Convention of the New England Water Works Association was held September 18-21 in Boston, Mass.

The list of 570 registered was marked by the exceptionally high percentage of active members in attendance —especially prominent on the list were the names of superintendents and managers of water works. The meetings were well attended, as were the manufacturers' exhibits. The program was well rounded out and the convention as a whole was the most successful one held by the N. E. W. W. A. in several years—another index of returning nationwide confidence which has dispelled the gloom of the late depression.

Honors and Awards

The Dexter Brackett Medal, awarded the author of the most meritorious paper published in the Journal of the Association during the year, was presented to Caleb Mills Saville, Chief Engineer, Metropolitan District Water Commission, Hartford, Conn., for his paper, "Some Phases of Southern New England Hydrology." The presentation was made by Arthur D. Weston, Chief Engineer, Massachusetts Department of Health, who recalled that Mr. Saville was making the winning of this award a habit, having won it twice previously.

Honorary memberships were conferred on two prominent engineers—Frank A. Barbour, Cons. Engr., of Boston, and James E. Binnie, an eminent engineer of London, England—the last named not being in attendance. Mr. Barbour, a Past President of the Association, was introduced by Harrison P. Eddy, President of the American Society of Civil Engineers, who paid fine tribute to Mr. Barbour, a Canadian by birth, a former business man, and an engineer of great ability who had served his adopted country so well and tirelessly during the World War.

Caleb Mills Saville, Hartford, Conn. Dexter Brackett Medalist for third time.

Leland G. Carlton, Registrar of Water, Springfield, Mass. New Treasurer of the Association.

New Officers

Returns from the count of election ballots revealed the following new and re-elected officers:

President—H. M. King, Superintendent, Water Department, Springfield, Mass.

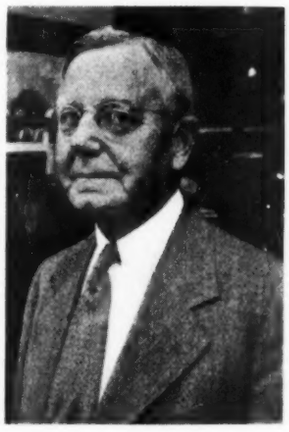
Vice-President—H. U. Fuller, Chief Engineer, Water Department, Portland, Maine.

Director—P. A. Shaw, Superintendent, Water Department, Manchester, N. H.

Secretary—Frank J. Gifford, Manager, Water Works, Dedham, Mass.

Treasurer—Leland G. Carlton, Registrar of Water, Springfield, Mass.

Editor—Gordon M. Fair, Harvard University, Cambridge, Mass.



Howard M. King, Superintendent, Springfield (Mass.) Water Department. The New President.

Harry U. Fuller, Chief Engineer, Portland (Me.) Water District. (President, Maine Water Utilities Assn.) Elected Vice-Pres. of the Association.

Reports of Secretary, Treasurer and Editor

Reports of the Secretary, Treasurer and Editor of the Journal revealed that the association now has a membership of 795. Income during the past year totaled $10,080, of which $5,231 represented membership dues and the balance represented principally the interest from invested funds and advertising income. Cash and invested funds amounted to approximately $17,000. Disbursements for the year had been $10,004, including the cost of printing and distributing the Journal at $5,411 and representing the lowest publication cost per member during the past ten years.

Excerpts from the Address of the President

In the annual address of the President, E. Sherman Chase, reviewed the happenings and developments during his administration. He pointed with satisfaction to

the upturn in membership during the year and to the fact that even with the move of Association headquarters into the Statler Building, the employment of a full-time Assistant Secretary, and other extraordinary expenses, the budget had been held to.

He commented on the fruitful efforts made by association members to kill a very undesirable legislative bill drawn to make legal the use of water supply reservoirs for recreational purposes, now prohibited by an old and valuable act administered by the State Department of Health. The objectionable bill was killed in committee before coming to a vote.

Mr. Chase revealed that the Executive Committee had decided to make an annual award to the author of the most meritorious operating paper presented during the previous year. Such was intended to encourage superintendents and other operating men to prepare more papers on operating topics. He pointed to the need of maintaining the Journal on a high plane, and advocated increasing attention to publicity in order that water works men and their importance to the community might become better appreciated. He urged the incoming officers to consider the important work of devising means of improving the status of the Water Works Superintendent in his community. There should be a more adequate recognition of his responsibilities, and more commensurate salaries. He urged water works men to throw off their cloak of too great modesty, to participate more in public affairs, and that they seek to get beneficial publicity for the Water Department.

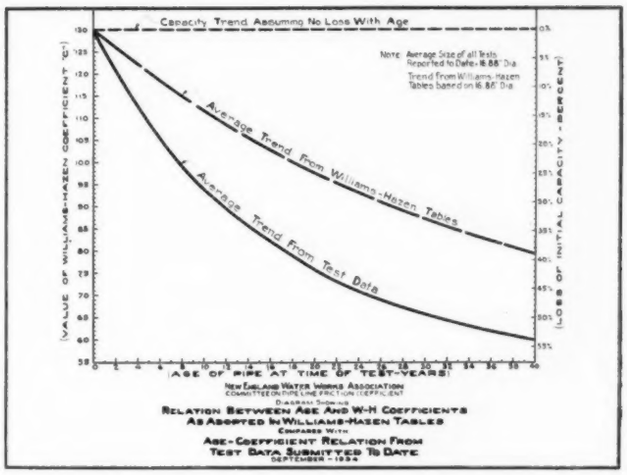
Seemingly to prove the soundness of Mr. Chase's recommendation concerning the value of publicity, the Mayor of Boston in his address of welcome explained apologetically that, until invited to address this gathering, he had not known of the existence of the New England Water Works Association. Following the Mayor, Dr. Henry D. Chadwick, Director of the State Department of Health, appeared in behalf of Governor Ely to address the Association.

Report of Committee on Pipe Line Friction

The most interesting of the committee reports was that presented by the newest committee—that established during the past year to study and report on Pipe Line Friction Coefficients. Its first progress report was presented by E. T. Killam, Consulting Engineer, of New York City, who is chairman of this active and important committee.

E. T. Killam, Consulting Engineer, New York City. Live wire chairman of New Committee on Pipe Line Friction.

Frank A. Barbour, Consulting Engineer, Boston, Mass. A past President of the Association, was made Honorary Member.


Capacity Trend Assuming No Loss With Age
Note: Average Size of all Tests Reported to Date-16.88" Dia.
Trend from Williams-Hazen Tables based on 16.86" Dia.
Average Trend From Williams-Hazen Tables
Average Trend From Test Data
(VALUE OF WILLIAMS-HAZEN COEFFICIENT "C")
(LOSS OF INITIAL CAPACITY - PERCENT)
AGE OF PIPE AT TIME OF TEST-YEARS
New England Water Works Association
Committee on Pipe Line Friction Coefficient
Diagram Showing
Relation Between Age And W-H Coefficients
As Adopted In Williams-Hazen Tables
Compared With
Age-Coefficient Relation From
Test Data Submitted To Date
September - 1934

Curve Presented by Committee on Pipe Line Friction Coefficients.

In the initial stages of their investigation, Mr. Killam reported that data submitted by 50 representative cities had disclosed extreme variations in the friction coefficient "C" on pipe lines or distribution mains of equal age. So marked has this been that curves had been drawn to compare the value of "C" as predicted from the generally accepted Williams-Hazen friction tables, most commonly used, and actually observes values on unlined pipes. The differences were marked and anticipated capacity losses of 33 per cent expected for 30-year-old pipe when using the W. & H. tables had been reached on the average after but 13 years of service—the value of coefficient "C" being 87. The variations entering into the average trend curve for unlined pipe (reproduced herewith), plotted from actual data, had been between 145 and 20 as the two extremes. In one instance a main had depreciated to a carrying capacity represented by the value of "C" as 55, and this condition, predicted after 64 years of service, had actually been reached after only 8 years of service.

Such initial observations warranted the decision of the committee to proceed with the idea of deriving a series of friction trend curves one or more of which would apply under the specific conditions at hand. This, rather than continue under the delusion that the application of a few well defined coefficients could be expected to serve under all conditions of water quality. In order to derive such trend curves, mass data would be resorted to, but weight would be given to the water quality factor. Such an accomplishment could only be had through widespread co-operation and the reporting of conditions as accurately as possible from numerous sources. Mr. Killam makes a plea for such co-operation from the whole field, in order to present as valuable a report as may be possible, in which lined as well as unlined pipe is to be evaluated.

In the discussion which followed this interesting report it was pointed out that modern water treatment had in numerous instances created a more corrosive water and that this had not been a factor in the days when the Williams and Hazen tables had been computed and values of "C" assigned to pipes of various ages. Experience of operating men also disclosed the greater protection afforded by tar dip coatings on pipes cast 30 years ago than those on pipes produced 12 to 15 years ago.

The P.W.A. and Its Accomplishments (A Symposium Presided Over by Frank A. Barbour)

Quite a bit of the program was given over to a symposium setting forth "Experiences With PWA and Other Agencies for Public Works Construction."

Prior to discussing the subject, Col. W. T. Chevalier, Vice-President, McGraw-Hill Publishing Company, had made an analysis of the place of "Public Works Construction in Economic Stabilization." In discussing the advisability of the Government departing from its purely civic functions and entering the field of economics, he felt that there was no reason to argue the extremes, viz.: (a) that Government should hold strictly to civic governing; or, (b) that it should participate in business to the extent of production and marketing. A happy medium in between was, to his mind, of practical adoption. The increasing participation of Federal Government in Public Works construction and financing was a definite in-between position and now the most important question was that of its regulation for the highest benefits. The complaint that governmental operations were necessarily extravagant was not necesarily true.

Taking it all in all, P.W.A. had not been as successful as anticipated because a lack of well defined plans created delay and budget fanatics had obstructed expansion and progress, but it had loosed money for Public Works financing when private banking had failed to do so. With the most difficult barriers hurdled, further P.W.A. progress should be expected to be increasingly successful. The basis for success involved increased knowledge of national resources; regional planning based on long-time expectations; cutting of political lines; planned financial structure endorsed by banking interests; and, the fitting in of local projects into the master regional plan. The P.W.A. program had resulted in putting Public Works thinking on a better basis than ever before; the status of municipal bonds had improved, and a sounder basis of municipal financing could be anticipated in the future. The question was: Can we afford to return to the hit-or-miss basis of procuring Public Works betterments?

R. S. Meriam, Professor of Business Economics at Harvard University, said that he thought Col. Chevalier overly optimistic and that only limited results could be expected from a P.W.A. program to end a depression. For the greatest effect a program of betterments should be soundly formulated and held in abeyance until near the end of the period of deflation. The difficulty was that of getting political factions to hold public works expenditures in restraint during periods of inflated prosperity. Elected officials with short tenure of office needed to be replaced by a more permanent political structure in order to make Public Works betterments a dependable backlog for economic recoveries. He felt the P.W.A. program had been lucky because it was initiated at a period when the depression had about run its course and recovery had already set in. There was little evidence that the P.W.A. program had helped the recovery in private business.

As to the last statement, Col. Chevalier replied that he felt that manufacturers of materials and equipment in the water works and sewerage fields would hardly agree with the professor.

"Experiences of the State P.W.A. Engineer" were related by H. J. Lockwood, State P.W.A. Engineer, New Hampshire, Vermont and Maine, Concord, N. H., and T. B. Parker, State P.W.A. Engineer of Massachusetts, Boston, Mass.

Mr. Lockwood reviewed the early difficulties and later improvements in P.W.A. methods of procedure. He felt that far too much detail, attention and time was devoted to small projects which could better be handled at less expense under less rigid requirements than set up under P.W.A. procedures. He also felt that the inflexible rule of awarding contracts to lowest bidders was not a logical requirement and should be altered. Hours and rates for labor and skilled men should be more flexible so as to conform to local practice and conditions.

Mr. Parker reported 268 approved non-Federal P.W.A. projects in Massachusetts, with 123 under construction or completed. He said that the strictness of rulings was designed to avoid later pitfalls. Authorization of changes in plans or specifications were very difficult to procure and changes in cost were impossible; allowances for "extras" absolutely prohibited. Force account projects had been most unsatisfactory. Overruns in cost had produced considerable difficulty and more trouble in this was anticipated. The best remedy was for the community to supply evidence that it had financial ability to take care of such over-costs. Wage schedules had given so much difficulty that new and more flexible schedules had to be drawn up and the P.W.A. Engineer allowed more leeway in his decisions.

"Experiences of the Consulting Engineer" were set forth by A. L. Shaw, Metcalf and Eddy, Boston, Mass. Mr. Shaw was critical of the long delays created incident to filling in and filing the legal forms required by P.W.A.; further, by investigations which followed. The engineer had had to suffer delay and added expense on P.W.A. projects. The forced use of unqualified labor and a rapid labor turnover had resulted in loss of efficiency and monetary loss to contractors to the extent that for protection they had found it necessary to add 25 to 40 per cent to ordinary labor costs. Some contractors had refused to bid on P.W.A. projects. Consulting engineers had found themselves subservient to P.W.A. supervisors—all without the lifting of the least responsibility from the engineer's shoulders. In addition, engineering costs had been materially increased by the routine and paper work and also because of the difficulty in getting changes in plans or procedures authorized.

Arthur D. Weston, Warren J. Scott and Earl Devendorf, reported on the status of P.W.A. projects in Massachusetts, Connecticut and New York. In Connecticut engineers paid by C.W.A. had been supplied municipalities to draft plans to be executed under experienced engineers later. Money allocated in each of the states had been twice to five times as great for sewerage as for water works projects.

Frank A. Barbour, Consulting Engineer, Boston, Mass., commented that the extra costs of projects under P.W.A. regulation will probably exceed the amount of the grant in many instances. The need for contractors to organize their forces on each new job in order to use local labor made it imperative to boost bids materially. If the contractor was allowed to bring his skeleton organization of key men onto a job that would facilitate matters materially and reduce costs.

He inquired of the State P.W.A. Engineers how an engineer on a P.W.A. project could secure a preferred make of equipment in the face of requirements that low-bidder be given the contract. Mr. Parker replied that where special authority was granted the practice of specifying certain equipment "or equal" could be resorted to. He agreed that the engineer serving the municipality should be the judge in selection of equipment and the policy of the P.W.A. office in Massachusetts was to recognize as much whenever practicable.

Mr. Barbour thought that more discretion should be

allowed state P.W.A. Engineers—the letter of the ruling being intended as a guard against unfair practices and connivance on the part of the consultant or supervising engineer. Mr. Lockwood explained that specifications had to be drawn so as to give an equitable opportunity to the greatest number of bidders and to avoid dissatisfaction by competitors excluded by too finely drawn specifications. He believed that in sub-contracting there should be greater leeway allowed in selecting materials and equipment more on merit and less on price. In this it was questionable just how far the state engineer could go because he would likely not be backed up at headquarters. R. S. Weston lamented the fact that the engineer was forced to build his "monuments" of materials and equipment which were not of his selection and therefore apt to prove unfortunate to his reputation in years to come.

Mr. Lockwood said that he had found the cost of P.W.A. projects about 15 per cent higher than if put through in the normal manner.

Taste and Odor Control
(A Symposium of Experiences)

"Experiences With Taste and Odor Control at Waterford, N. Y."—R. G. YAXLEY, Supt., Water Works, Waterford, N. Y.

The source of supply—the Hudson River—is polluted with wastes from pulp and paper mills, woody tastes being the most common. Having tried various schemes including pre-ammoniation, Mr. Yaxley had found heavy pre-chlorination (without ammonia) followed by 2½ hours of basin contact, and the addition of powdered carbon to the applied water at the filters, to be the most effective taste corrective process. Having a plant so designed as to make it possible to split it so as to be in effect two plants of two filters each, operating in parallel, had made comparisons of treatments possible.

To procure 0.2 p.p.m. or more residual at the filters, prechlorine dosages of 3 p.p.m. at times had been required. The application of carbon averaged 20 lbs. per million gallons treated (2.4 p.p.m.), and the method followed was at intervals of two hours to apply 2 lbs. of carbon to the filter influent during a period of approximately 10 minutes. A secondary dosage of chlorine had been applied to the effluent to maintain 0.1 p.p.m. residual —the result being a completely satisfactory and practically tasteless finished water.

The heavy prechlorine dosage had made it possible to coagulate the water at a higher pH value and thereby a 5 per cent net saving in treatment costs had resulted, notwithstanding the higher chlorination cost. The output of the Waterford plant is averaging 1,200,000 g.p.d.

R. G. Yaxley, Superintendent, Water Department, Waterford, N. Y. Believes in experimentation, gets results.

Elwood L. Bean, Supt., Filtration, Providence, R. I.

GEORGE C. HOUSER, of Metcalf and Eddy, Boston, Mass., related experiences at Rockport, Mass., with copper sulphate applications to shallow Cape Pond to control tastes created by algae growths. In years past 6 lbs. per million gallons applied in three treatments had been effective—reducing organisms 96 per cent within 10 to 18 days after each treatment. In recent years, however, the treatments had not been so effective and apparently there had been built up a strain of organisms resistant to copper sulphate and the efficacy of the treatment in the future seemed in question.

J. M. CAIRD, Consulting Chemist, Troy, N. Y., discussed the causes and the evaluation of tastes and odors. Particularly noticeable had been the production or building up of tastes and odors in dead-ended mains due to decaying materials in those sluggish areas. He reviewed the various corrective treatments such as aeration, ammoniation, permanganate, ozone, super and dechlorination, activated carbon. It was his opinion that no one method would be applicable to all conditions and, therefore, experimentation would be required in order to select the most effective treatment or combination of processes for the particular condition at hand. He recommended covering service reservoirs and the liberal use of the bottom blow-off on deep supply reservoirs for wasting the objectionable bottom water—ofttimes putrid.

GORDON M. FAIR, Harvard University, Cambridge, Mass., said that tastes in water supply was not a recent difficulty because in the Pickwick Papers reference could be found to a water which was described as tasting like "hot flat-irons." He then described the improved Osmoscope, developed by himself and Mr. Wells, and its use in evaluating odors by the air dilution procedure. The new Osmoscope automatically mixes atmospheric air with vapors above water samples in flasks, while the observer is sniffing through the instrument. Thus two observers can secure numerical odor values of fair agreement—these being expressed in terms ranging from pO zero (odorless) to pO 6.

Professor Fair called attention to the fact that copper sulphate as an algacide was 30 years old but that the published tables of dosages required to destroy specific organisms could not be completely relied upon. He felt that revisions were needed and suggested that a committee be named to correlate results with dosages in modern practice. Professor Fair has since accepted the appointment to serve as chairman of such a committee.

F. E. STUART, Industrial Chemical Sales Company, New York City, reported that success had been attained with the application of powdered carbon to reservoirs, following a treatment with copper sulphate. The combination had given results superior to the use of either material alone. The copper compounds formed seemed to drag down the finely divided carbon and clear the water of the smallest particles resisting plain sedimentation.

L. H. ENSLOW complimented Mr. Yaxley on the investigations and experimentation at the Waterford filter plant. The ultimate treatment was in line with what had proved the most successful scheme elsewhere. In effect, it amounted to taste destruction by super-chlorination of the organic water under such circumstances was so free of chlorine demand that only small residuals could be carried following the post chlorine application if a taste of chlorine, itself, was to be avoided. It was on this score and for added advantages on the distribution system that post-ammonia treatment was favored rather than pre-ammoniation.

Superintendents' Round Table

(Presiding—D. A. Heffernan, Supt., Water Dept., Milton, Mass.)

"Spacing of Hydrants and Placing of Gates—With Particular Reference to Their Insertion in Old Distribution Systems."—THOS. E. LALLY, Engr., Water Division, Department Public Works, Boston, Mass.

Mr. Lally said that the policy of his department was to space hydrants every 250 ft. in congested districts, every 300 ft. in residential areas. Regardless of claims of manufacturers to the contrary, they were using more gates ahead of hydrants and found that it pays. On the distribution mains and feeders their policy was to locate a gate every 600 feet—employing three types of gate valve boxes. The larger were of concrete with slab covers. The Jumbo box was of iron, shaped like an inverted funnel, had a 14-inch opening with manhole cover, weighed 500 lbs. It was a practical box because it did not fill up rapidly with trash. On valves 4 inch and smaller the housing was a section of flanged pipe.

As to inserting gate valves, programs were frequently delayed due to fear of consequence if something happened while the pressure was off of the section cut out of service. With the modern tapping machines the job was simplified and tapping under pressure avoided dangers of taking sections out of service for the purpose of cutting into the line.

The difficult question of where to locate a fire hydrant, when its removal or relocation was requested by residential property owners, had been solved by placing the hydrant squarely on the property dividing line between two adjoining lots. A charge of $125.00 was standard for such relocations. In reply to questions Mr. Lally said that Y branch connections to hydrants were preferred to using a sleeve in making an offset. Gate valves seldom needed repacking but when so it was necessary to dig out any under 16 inch—i.e., all not located in the concrete boxes. J. H. Sweeney of Manchester said that they used "squeezers" to stop stem leaks and seldom found repacking necessary. H. M. King of Springfield said that flanged bolted connections for gates to hydrants had been more satisfactory than leaded connections where high pressures were maintained.

"Metering"—H. W. GRISWOLD, Deputy Chief Engineer, Metropolitan Water District, Hartford, Conn.

Mr. Griswold offered for discussion the "Proposed Rules, Regulations and Standards for Water Companies," drawn up by the Public Utilities Commission of Connecticut. He commented on those sections pertaining to meters and metering practices. The following were among the items cited: To avoid conflict with a Connecticut statute, if on test a meter is not more than 4 per cent fast no refund can be demanded by the customer, but it must be replaced and a meter within 2 per cent accurate substituted. Testing small meters in place had been the most satisfactory scheme in Hartford—a hose and calibrated can being employed. In testing meters, three rates of flow were required—full capacity rate, ¼th rate and 1/25th rate—the average being taken in computing accuracies.

Frequency of meter tests called for the following intervals between tests:

⅝ in. after each	200,000 cu. ft. or 5 years' service
¾ in. after each	500,000 cu. ft. or 5 years' service
1 in. after each	1,000,000 cu. ft. or 5 years' service
1½ in. after each	2,500,000 cu. ft. or 5 years' service
2 in. after each	4,000,000 cu. ft. or 5 years' service
3 in. meters every 3 yrs.; 4 in. every 2 yrs.; 6 in. every year.	

D. A. Heffernan, Superintendent, Water Service, Milton, Mass. (Past Pres. N. E. W. W. A.) Starts Round Table Discussions; keeps them going.

F. W. Gilcreas, Chemist, New York Department of Health.

Mr. Griswold's opinion was that 2 inch meters should be tested more frequently than every 4th year and all larger sizes every year. The small water company would operate to meet the regulations but the larger ones would go beyond them and profit by so doing. In reply to a question he said that municipally owned utilities in numerous cases reported to the Commission, but were not required to do so.

W. C. HAWLEY, General Superintendent, Penna. Water Company, Wilkinsburg, Pa., said that his company's policy was to exceed the Pennsylvania Commissions' regulations in respect to limit on time between meter tests—they had found it paid to make tests every 7.5 years on ⅝-inch meters whereas the ruling was very 10 years. He thought the Connecticut ruling on main extensions a valuable one. MR. MCLEAN, Superintendent, Water Works, Holyoke, Mass., thought that rulings on rate structures should be included in such regulations.

In reply to the question of "How was the size of meter installed determined in Hartford?" Mr. Griswold said that in 80 per cent of the cases the customer was allowed to select the meter because the size was the basis of the minimum charge. For the larger customers a survey was made before recommending the meter size and if the customer objected later, an agreement to substitute a larger meter protects him, in which case a compound meter is installed. In repairing or replacing frozen meters the customer is charged only the actual costs at Hartford.

"Action of Waters on Service Piping of Various Materials"—F. WELLINGTON GILCREAS, Director, Water Laboratories, New York State Department of Health, Albany, N. Y.

Mr. Gilcreas said that in selecting service pipe the relationship between the water quality and materials available had not been given consideration warranted. Galvanizing on steel pipes might be of value but it did not last long in contact with waters of either very low or fairly high pH value. A softened water (pH 9. or above) would soon remove the zinc as would the aggressive low pH waters. Lead was also soluble in low and high pH waters. Brass was usually more universally satisfactory but at low pH values the zinc was taken away, leaving a spongy easily fractured copper structure. Even copper would be attacked by waters of pH 6.5 and under—notably by well waters. Cement lined pipes lost the lime salts from the lining but left a satisfactory protective coating. He considered treatment such as aeration to remove carbon dioxide or lime added to build

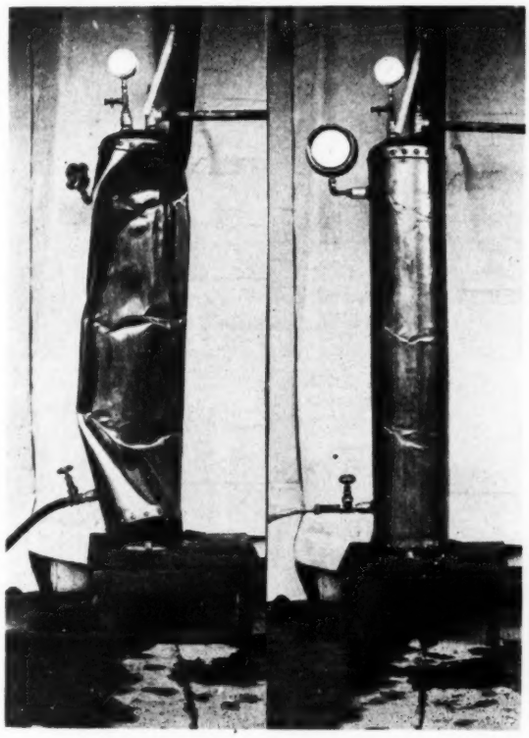
up the pH and perhaps to deposit a slight protective coating the proper corrective to apply where corrosion proved a problem. It was, therefore, evident that specification of the most satisfactory service pipe material was not a simple matter and that in doing so water quality and its treatment had to be considered.

A. V. HERRINGTON, Assistant Engineer of the Massachusetts Department of Health, said that the Reports of the Massachusetts Department of Health for 1898, 1900 and 1920 discussed service piping and that further studies were being undertaken in 1934 under newer conditions to amplify these earlier reports. Studies had been made on the effect of grounding electric circuits on household piping. He reported that the results of varying amperage from 0.5 to 3 amps. on copper tubing had revealed no direct relation between current applied and the rate of solution of the copper and the attack by d.c. current was stronger than a.c.

GEO. O. ADAMS, Director, Lawrence Experimental Station, reported no change in taste or odor, alkalinity or carbon dioxide could be charged to the flow of current on service pipes. This was contradictory to effects reported from Hackensack, N. J.

Mr. Gilcreas, in replying to questions, said that the new soft Albany water was lime treated to pH 9.4 at the filter plant and after its 10 mile travel the pH was still 9.2 at the taps. Copper or red brass pipe would not be attacked at pH 7.6 to 7.8. On the whole a protective coating laid down by lime treatment was the important element in suppressing corrosion—this could best be done by treating to procure a pH value of between 8.4 and 9.4 depending on the water being treated.

L. H. ENSLOW explained that the mineral content of the water was the ruling factor—very soft waters such as that of Providence or Albany would require the adjustment to pH 9.4 or better whereas waters with a calcium bicarbonate content above 35 parts could be adjusted to a lower pH value—for example, Baltimore with a hardness of above 60 got results with adjustment to pH 7.8 or 8.0. One must know the water quality in order to define the treatment to stay corrosion by pH regulation.



What happens to Copper Boilers with sudden drops in pressure on Distribution Mains as demonstrated at Nashua, N. H.
On left: After being subjected to a 30-in. vacuum, crumpling having started at a 6 in. vacuum only.
On right: A few minutes after turning back the water at full pressure of 180 pounds—badly wrinkled but no leaks.

"Freezing and Thawing of Mains and Services"—ALBERT A. ROSS, Superintendent, Water Works and Sewerage, Lexington, Mass.

Mr. Ross reported that most of their service freezing had occurred under the street, between the curb and the main. His experience with a small portable electric thawing machine and a welding machine to produce 400 to 500 amperes, led him to favor the welding type of machine as the most satisfactory thawing device. Its usefulness as a welding device added to its value as a piece of water works equipment. Between 5 minutes and 90 minutes of current flow was required to thaw, depending upon materials in main or service and length of section being thawed. Their method was to connect one wire to a hydrant and the other to the service pipe. Wires not smaller than size 000 should be used. Where compound joints interfered with current flow steam had to be used. Tubercules had been torn loose by the ice and some taste complaints were had during thawing operations. He believed that the expense of thawing should be a divided responsibility between consumer and Water Department, for they had sent out special notices to protect meters and waste water, with the assurance that the bill would be adjusted.

JOHN P. MILLER, Assistant Commissioner, North Andover, Mass., reported that they had operated 4 electrical thawing outfits and considered the welder type preferable to the transformer type which had also created more damage. The welder had been used to repair a split in a main across a bridge. Another member reported having satisfactorily used 4 welding outfits with 300 amp. capacity. Copper services had required 10 to 12 minutes to thaw as against 4 to 5 minutes for iron pipe.

HARRY MANSON, Superintendent, Water Works, Lebanon, N. H., reported no difficulty in electrically thawing copper services up to 100 ft. lengths.

"Responsibility of Water Utility for Collapse of Hot Water Boilers"—W. F. SULLIVAN, Pres., Pennichuck Water Company, Nashua, N. H.

The question discussed by Mr. Sullivan was a neat one. Is the city or the water company responsible for the collapse of hot water boilers created by the vacuum set up when a broken main or water cut off on the distribution system occurs. He pointed out that as little as a six-inch vacuum on some copper boilers causes a sucking in of its sides and as the vacuum increases the collapse progresses. Interestingly a sucked in boiler returns to its shape when water pressure is renewed—leaving only a few wrinkles in the metal as illustrated. As Mr. Sullivan stated, the effect on the housewife is a weird one when one minute she sees a crumpled boiler, and before her eyes it again balloons out to its original shape except for the wrinkles.

J. W. ACKERMAN said that in Fall River a District Court decision held the city liable—he paid the bill and the decision was not appealed.

MR. HEFFERNAN said that notices (samples passed around) were always sent out at Milton when water was to be shut off. The notice called attention to the need of leaving faucets open to prevent damage and in the face of such notification the town could not be held responsible. It was a ruling in Boston that a vacuum relief valve be provided in the system but the Water Department settled for damage to boilers.

"Joint Use of Service Trenches for Different Utilities"—LEON A. GOODALE, Water Commissioner and Registrar, Worcester, Mass.

In weighing the good and bad in the practice of joint use of service trenches, Mr. Goodale said that he was not in favor of a practice which fell far short of the theory. He felt that because of lack of jurisdiction general confusion would result if water, gas, electrical and sewer conduits were all laid in a single trench—not to mention the telephone cable. He cited typical results in Worcester wherein the water service pipes had sprung leaks due to faulty support beneath. The Water Department had borne the brunt of the criticism of faulty construction. Since the Water Department of Worcester takes the responsibility of service lines up to the meter, he felt that it was proper that coöperate trenching and pipe laying be placed under its jurisdiction and supervision, if such practice was to prevail. Otherwise it would be a black-eye in the end. To dodge responsibility and collect for leaking water it had been arranged to locate the meter at the curb in some cases and let the contractor and owner stand the expense of maintenance of the line in such coöperate trenching practice.

Tuberculation and Its Effect

"Tuberculation and Incrustation of Supply Conduits and Distribution Mains in Relation to Their Carrying Capacity"—ROBERT HORTON, Consulting Engineer, Voorhesville, N. Y.

Mr. Horton concurred with the report of the Committee on Pipe Line Friction Coefficients (elsewhere in this issue) by saying that there was quite a disparity between actual tuberculation (friction) in mains and that derived by applying any of the commonly used formula. This situation had resulted in his drafting a revised tab'e of pipe depreciation. He had thought of the practicability of drawing up a limited group of formulae which might be selected from to apply under varying conditions—with especial consideration given the variable quality of waters. It would be necessary to differentiate between incrusting and tuberculating (nodulating) waters. The Williams-Hazen formula had apparently been based on tuberculating effects. The nodulations produced by iron fixing (depositing) bacteria were quite different in shape and structure to tuberculation which was chemically produced—the iron oxide biologically deposited being laid down in concentric rings of soft structure, indicating a cylic growth. The limits of loss in pipe capacity due to biological iron deposits seemed to be 50 to 60 per cent. Tubercules created loss of head principally by the setting up of internal flow eddys and therefore the extent of this effect was a function of the shape of the nodule or tubercule. A formula had been developed which involved the use of factors derived from the volume of deposit reducing the pipe area and roughness characteristics. On the screen he showed sections of distribution mains of various ages which had been studied at Utica, N. Y. Some had been in service from 1849 while others had various ages, some had been supplying soft water and others a water of about 100 p.p.m. hardness—one encrusting, the other nodulating.

He also reviewed the history of the 12 mile 42 inch cast iron gravity main at Utica on which records of gradually increasing friction losses had been carefully kept for many years. From the data available, the formula for this main was

$$C = 90 + 52_e^{-0.77t}$$

t = number of years since cleaning.

Cleanings had returned "C" to 142 which dropped in 1.5 years to 110.

J. WALTER ACKERMAN, Assistant General Manager, Utica Consolidated Water Company, Utica, N. Y., reported that the transfer of the point of chlorination and introduction at the same time of ammoniation at the supply reservoir feeding the 12 mile pipe line, referred to by Mr. Horton, had apparently held tuberculation in check and maintained high capacity. Since the cleaning given in April, 1934, the value of "C" had held at 145 or better and examination had shown a slime like film on the pipe but no nodulating was in progress. Past experiences had been that 2 months after cleanings the carrying capacity of the main had dropped 20 per cent, slowing up thereafter. Opportunity had been given for accurate measurements of head loss due to friction and there seemed reasonable certainty that the ammonia-chlorine treatment was destroying the iron depositing organisms. The chlorine dosage had been on the average 6 lbs. to the million and 20 per cent as much ammonia. The pH of the water averaged 6.7 and alkalinity only 30 parts.

PROFESSOR FAIR took issue with the theory that tuberculation was due to biological action. In his opinion the acidity and oxygen content of the water were the responsible factors. Tuberculation was generally more pronounced when examining the Utica pipe specimens. MR. HORTON replied that extensive bog iron ore beds were created by bacterial depositions and the same organisms had been identified in the nodules on the pipes.

E. L. BEAN remarked that absence of nodules at the ends of the distribution system could be explained if the iron had already been deposited enroute through the supply main and feeder mains. ROBERT SPURR WESTON said that tuberculation might well be created by both biological and chemical phenomena—the former requiring that iron be present in the water naturally or through chemical corrosion.

"Recent Improvements in the Centrifugal Casting Process"—H. A. STUART and S. E. LINDERMAN, U. S. Pipe and Foundry Company, Burlington, N. Y.

Mr. Stuart told of research (started in 1930) which had led to the discovery of the improved method of centrifugal pipe casting and the product Super De Lavaud Pipe. The secret of the markedly toughened, more ductile and shock proof pipe lay in the fact that the rapid chill of the molten iron, when striking the water cooled steel mold, had been eliminated. Further, the improved annealing process through which the hot pipe was passed had enhanced the qualities desired by reducing the free carbon to 0.1 per cent or less. There had been no change in the quality of iron used nor the make up of the charges to the furnaces. The slower

H. W. Stuart, Engineer, U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.

J. Walter Ackerman, Asst. General Manager, Consolidated Water Co., Utica, N.Y.

Chas. W. Mowry, Manager, Inspection Department, Factory Mutual Fire Ins. Co.

Arthur D. Weston, Chief Engineer, Massachusetts Department of Health.

cooling had merely changed a crystalline surface structure of the pipe to a dendritic (tree like) structure all the way through and a more homogeneous structure resulted. The interlacing branches of the dendrites had made the metal tough and shatter proof and also more easily drilled and threaded or machined. The secret of the process, which he described and illustrated on the screen, was the blowing onto the revolving mold a film of ferro-silican dust just ahead of the on-flowing molten iron. The dust was actually a film only 3/10,000ths of an inch thick, requiring a very small amount—200 grams for a pipe of 12 in. diameter and 18 ft. long. Test data thrown on the screen revealed the comparative results from the impact test applied to the old and the improved De Lavaud pipe.

In reply to a question, Mr. Stuart said that in the impact test the new pipe compared favorably with pit-cast pipe.

(*Note.*—For greater detail, the reader may examine an article in WATER WORKS AND SEWERAGE for February, 1934—under the title, "What Is Super De Lavaud Pipe?")

Status of Cross Connections

"Status of Cross Connection Regulations"—C. W. MOWRY, Manager, Inspection Department, Factory Mutual Fire Insurance Company, Boston, Mass.

Mr. Mowry in his usual clear-put style gave an excellent review of the cross-connection situation. That progress was being made or could be made in eliminating or making cross connections safe was proven when one municipality in California reduced 408 cross connections to 88, within an 8-month period. All of those now existing are equipped with double checks. There were now 750 installations of all bronze double checks and 1,000 others with iron bodied valves were in service in America. In New York State 65 chlorinators which automatically kick into service with the fire pump have been installed. Eleven states now require the complete severance of the connection or else the installation of approved bronze checks and two states required automatic chlorinators in addition.

He was of the opinion that the majority of cross connections were not necessary and could be eliminated. The remaining could be protected with double bronze checks and chlorinators if need be. Connecticut regulations, he said, called for 3 inspections of double check installations annually.

MR. ACKERMAN stressed the need of eternal vigilance in connection with existing cross connections. A check-up would be necessary to prevent unauthorized and dangerous additions being made without authorization.

Filters and Filtration

"The New Filtration Plant at Baintree, Mass."—ROBERT SPURR WESTON, Consulting Engineer, Boston, Mass.

Mr. Weston described conditions of the Baintree supply (color 20 to 100 and taste troubles) which led up to the recent construction of a filtration plant. Experiments had revealed a combination of alum and sodium aluminate to be the best coagulants. Activated carbon was being applied in small dosages to the raw water and chlorine and soda ash to the filter effluent.

Features of the plant (2.5 m.g.d. capacity) included a Sterling gasoline engine as stand-by unit, automatic wash water pumps to wash tank, square mixing chamber (15 minute) with revolving paddles (2 r.p.m.) and inlet at bottom center. Then followed a 3 hour retention in coagulation basins. The filters were equipped with Wheeler type bottoms consisting of pyramidal insets in a false bottom, with balls in the insets to distribute the wash water. Sand of 0.45 to 0.5 effective size and uniformity coefficient of 1.6 was used in 30-inch bed on 18 inches of graded gravel. Clear water storage was 500,000 gals. Simplex Rate Controllers, International Operating Tables, Bacharach Chemical Feeders for alum, aluminate carbon and soda ash were selected. A holding basin was built to catch dirty wash water and drainings from the coagulation basin, the clear top water being returned to the lake.

Mr. Weston attributed the excellency of filter washing and cleanliness of bed to the false (Wheeler) bottom.

"Experimental Studies of Porous Plates for Use in Rapid Sand Filter Bottoms"—T. R. CAMP, Professor, Sanitary Engineering, Massachusetts Institute of Technology, Boston, Mass.

Professor Camp discussed the hydraulics of orthodox rapid filters, the distribution piping arrangement constituting the underdrain, and their shortcomings. He had been interested in the possible adaptation of a false bottom scheme employing rigid porous plates to serve as distributors of wash water. Such a scheme would have the advantage of efficient wash water distribution and filtrate collection; would eliminate the use of gravel and have other distinct advantages. Coöperatively with the Norton Company of Worcester, Mass., experimental glass sided, false bottomed units had been constructed and various plates tested at the Providence (R. I.) filter plant. Such matters as the loss of head, effectiveness of distribution of wash water, rate of clogging of plates and methods of cleansing had been studied. Some clogging was in evidence, but wash water requirement had been very low—only 0.4 per cent. Loss of head with increased rates of filtration had been almost straight lines because of the viscous type of flow through the plates rather than the high velocity turbulent flow prevalently involved. Plate clogging to 8 ft. head loss had no ill effects other than loss due to friction.

Someone suggested that possibly a very shallow (12 in.) sand bed might be used with the plates and reduce filter construction costs considerably. Prof. Camp said that a bed depth greater than 12 inches was advisable in order to protect the plates against too rapid clogging.

A Century of Water Works Developments

"The Water Works of St. Johns, New Brunswick"—RUPERT W. WIGMORE, Commissioner of Water and Sewerage, St. Johns, N. B.

Mr. Wigmore, the first Commissioner of Water for St. Johns and serving continuously since 1912 in that office, described the first public water supply system of St. Johns established just 100 years ago (1834) and

briefly reviewed water supply developments since. The present supply comes from two chains of softwater lakes—one on each side of the city. The average daily consumption of 20.3 m.g.d. represented a per capita demand of 275 gallons—this apparently high demand being due to a large industrial demand (paper and pulp mills), one of which took 6 million per day. Industrial water was sold at 1½ per cent per 1,000 gals. and a 2.5 cent rate per 1,000 constituted the maximum for hotels, laundries and the like; with all residences on a flat rate. No charge for fire service was made and static pressure of 80 lbs. was carried. The latest improvement to the system had been a new Lock Joint Concrete supply main. In the system was some of the original cement pipe reinforced with sheet iron, now in service 75 years. In all there was 154 miles of water mains and 50 miles of sewers in St. Johns, 800 men being employed making concrete pipe and constructing sewers last year.

Changing from quarterly to monthly billing had resulted in improved water rent collections and Mr. Wigmore was justifiably proud of the fact that the St. Johns Water Works had been more than self-supporting during his administration—this to the extent that $850,000 net profits had been turned into the general tax fund of the city.

Frank A. Barber of Boston, who had been connected with the development of the supply, commented that the supply lakes, especially Lake Latimer, was a beautiful body of water surrounded by virgin timber lands. In addition to plentifulness, the supply was soft and otherwise highly satisfactory in quality.

"Financing Water Works Extensions by the Betterments Assessment Method"—S. R. WRIGHTINGTON, Town Counsel, Lexington, Mass.

Mr. Wrightington said that the former procedure of financing water main extension at Lexington required benefited property owners to pay 6 per cent interest on the cost of the project and to guarantee the bonds floated for the purpose. This scheme had not proved sound and the bond guarantees had not proved to be a reliable security. The prevailing newer method of financing was done by making an assessment against real property benefited by the main extension or enlargement—no bond guarantee be required in this scheme. The total assessment was in effect a tax, divided for collection during a period of 10 years, and became a first lien on the property assessed. The procedure followed was the issuance of a formal order by the Town Board to proceed with the betterment, the project first being described carefully so as to show a plan, the area served, property owners and costs. Six months after completion of the project, proof must be given of special benefits to the property assessed. All vacant lots had been held to benefit by their proportionate share. The scheme seemed to be working.

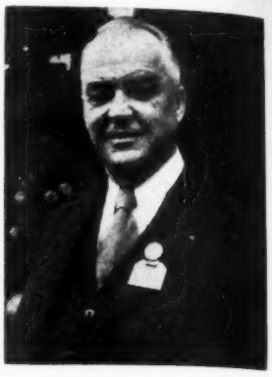
CALEB M. SAVILLE reported that Harford Water District employed essentially the same scheme in which the estimated cost of laying pipe during the previous 5-year period was used as the basis.

"Status of Metropolitan District Water Supply"—FRANK E. WINSOR, Chief Engineer, Metropolitan District Water System, Boston, Mass.

Mr. Winsor said that already $80,000,000 had been spent on the Ware and Swift River projects of the Boston Metropolitan District, the work being scheduled for completion in 1940. To date 58,000 acres of land had been purchased and 3 towns were to be wiped out completely. In the construction of the 13 ft. tunnel, 25 miles through solid rock, careful geological records had been kept.

(For a full description of the Swift and Ware River projects, see June, 1934 issue of Jour. of the New England Water Works Association.—*Ed.*)

Frank E. Winsor, Chief Engineer, Boston Metropolitan Water Commission.



Rupert W. Wigmore, Commissioner of Water and Sewerage at St. Johns, New Brunswick, for the past 22 years, has turned back $850,000 profit on the water utility.

▼

A. H. Miller Made Chairman of the Wisconsin Section

At the recent meeting of the Wisconsin Section of the A. W. W. A. the following officers were named for the ensuing year:

Chairman: A. H. Miller, Superintendent Water, Sheboygan, Wisc.

Vice-Chairman: Clarence Grentzmacher, Water Department, Milwaukee, Wisc.

National Director: L. A. Smith, Superintendent Water, Madison, Wisc.

L. F. Warrick, Retiring Chairman, and C. P. Gross were named Directors of the Wisconsin Section. L. A. Smith was re-elected Secretary-Treasurer.

By resolution, L. F. Warrick, as Chairman, appointed a Committee on Licensing of Water Works Operators to investigate and report, with authority to coöperate with similar committees of other organizations. A resolution was passed also which petitions the Wisconsin Public Service Commission to prepare and sponsor an amendment to the existing law which will clarify the relationship between water utilities and the municipality served.

▼

W. B. Marshall Addresses Wausau, Wis., Rotary Club

It is seldom that Rotarians invite outsiders to explain "How to Digest Mixtures of Garbage and Sewage Sludge" at their weekly luncheons. Nevertheless, W. B. Marshall, Manager of Chain Belt Company's Sanitation Division, was so honored by the Wausau (Wis.) Rotarians recently and they liked it—the discussion, not the garbage and sludge.

Sewage treatment at Wausau is a live topic and Mr. Marshall, according to a press dispatch, told the Rotarians the "why and the how"; also that 648 municipalities in America have recently installed or contracted for sewage treatment facilities at a cost of $212,000,000. That's not such bad progress in sanitation—thanks to P.W.A. and State Sanitary Engineers.

CHLORINATION OF SEWAGE[1]

Some Factors Affecting the Efficiency of Chlorine in Sewage Treatment

By WILLEM RUDOLFS, Ph. D.[2]

Dr Willem Rudolfs

RECENT studies, made for the purpose of throwing more light on observed effects from the chlorination of sewage, have shown that a number of factors affect the efficiency of chlorine to a greater extent than has been heretofore appreciated. Some of the results indicate that under certain conditions considerable saving of chlorine may be effected; others show how the efficiency of the chlorination process might be increased without additional cost. It is intended to briefly discuss in this paper some of the results; and, to point the way to practical applications. The reader desiring information in greater detail may examine two recently published papers (1, 2) and another (3) to appear shortly.

Chlorine Dosage

Until recently it has been assumed that in order to obtain a substantial reduction of total bacteria and B. coli sewage should be completely chlorinated and preferably that the treated sewage show a positive test for residual chlorine. A set of experiments were conducted to include a number of trials, in which sewage was chlorinated to different percentages of its total chlorine demand. The average results are graphically pictured in Fig. 1—the curves being plotted to reveal effects after 7.5 minutes of contact between the chlorine applied and the sewage. With an increasing dosage (beginning with 10 per cent of the 10 minute chlorine demand) the kill of 20 degree organisms and B. coli increases progressively. With a 7.5 minute period of contact and practically complete chlorine demand satisfaction, but no residual, the average count of 20 degree organisms was reduced over 98 per cent and the B. coli (confirmed) over 99 per cent. With but 60 per cent of the chlorine demand satisfied, at the end of the same (7.5 min.) contact period the percentage reductions were 95 and 85, respectively. It is obvious, therefore, that the presence of residual chlorine is not necessary in securing an important bacteria kill; further, that the percentage bacterial reduction is greater than the figure representing the extent (per cent) to which the whole of the chlorine demand has been satisfied. For example: a 90 per cent kill may be secured with a chlorine dosage representing 30 per cent of the demand.

Contact Periods

The effect of contact period upon the percentage bacterial reduction is illustrated in Fig. 2. The relation between percentage chlorine demand satisfaction and kill within different contact periods, shows that bacterial reductions increase not only with the chlorine dosage but also with the time of contact. A few figures will illustrate the significance of this second set of curves. For instance, in order to kill more than 99 per cent of all forms of bacteria, 100 per cent of the chlorine demand must be satisfied if the contact time is 8.5 minutes; with 80 per cent chlorine demand satisfied, for the same result the contact time must be 10 minutes; with 40 per cent chlorine demand satisfaction not less than 25 minutes is required. When 90 per cent bacterial kill is sufficient, 2.5 minutes contact time is enough with 100 per cent chlorine demand satisfied; 10 minutes with 50 per cent; 30 minutes with 35 per cent chlorine demand satisfaction. To put it differently: If more than 99 per cent bacterial reduction is desired, only half of the total chlorine demand is required on some effluents if the contact time is doubled. It may be concluded, therefore:

(1) The reaction time between chlorine and sewage affects the extent to which the bacteria in general are killed; so that, in general, the longer the contact time the greater the per cent reduction in bacteria.

(2) The amount of chlorine added, in respect to satisfying the chlorine demand, affects the extent to which bacteria are reduced in the sewage.

(Note:—It should be understood that these results were obtained with efficient initial distribution of chlorine through the sewage—the importance of good initial distribution being discussed and emphasized elsewhere in this paper.)

Interfering Substances

It is logical to assume that the types and amounts of substances which may interfere with the kill of bacteria when liquid chlorine is added to sewage, would vary with the character and type of the sewage treated. If there are many substances which interfere the possibilities of difficulties with different sewages would increase.

In addition to gases and salts in solution, materials which might possibly interfere may be classified as (1) nitrogenous; (2) carbonaceous. These substances are in solution or suspension, or may be so finely divided that they approach solution. It has been found that

This constitutes the first of a series of articles dealing with Sewage Chlorination by Dr. Rudolfs and members of his staff.

In this article is discussed certain practical aspects of sewage chlorination, designed to stress features productive of effective results and economy of chlorine usage. Particularly are the effects from partial chlorination, long contact periods and efficient chlorine distribution stressed.

In subsequent articles "The Effects of Chlorination on Activated Sludge," as revealed in carefully controlled laboratory studies, is to be presented.—Editor.

[1]Journal Series paper N. J. Agricultural Experiment Station, New Brunswick, N. J., Dept. Water & Sewage Research.

[2]Chief, Dept. Water & Sewage Research.

with the exception of hydrogen sulfide, gases usually occurring in sewage have little or no effect. In the presence of decomposing sludge the story may be different, depending upon a number of conditions. Any material in suspension may interfere to some extent, but those in a very finely divided state and the organic substances in solution exert the greatest influence. It has been shown previously that carbonaceous substances (sugars and the like) in solution or suspension have practically no effect. Nitrogenous substances on the other hand require large quantities of chlorine to satisfy the demand. Materials in solution such as urine or in colloidal suspension, like milk or gelatine, and suspended solids coming from certain trade wastes (gas house, creamery, tannery, slaughterhouse, etc.) have a considerable chlorine demand and interfere with bacterial kill. Bacteria themselves are proteineous in nature and react rapidly with chlorine. Since decomposing organic solids are broken down by liquefactive processes into less complex and often soluble materials it is logical that the chlorine demand increases with the staleness of the sewage. As a consequence, it becomes more difficult to secure kill of organisms in stale than in fresh sewages. For instance, it is well known that septic tank effluents requires much more chlorine than the fresher effluents from mechanical settling tanks. Again, less chlorine is required in winter than in summer when sewage ages more rapidly. Since decomposition progresses in a septic tank and the liquified material is discharged in the effluent, the increase in interfering substances retards and even prevents kill unless a sufficient quantity of *residual chlorine* is present.

Chlorine Absorption—Importance of Efficient Distribution

The question of the rate of absorption of chlorine in different types of sewages is important in connection with (a) the velocity of kill, (b) amount of interfering substances, (c) effect of chloro-products formed and (d) distribution of chlorine. Experiments conducted (3) show that 95 per cent of the total chlorine demand of stale sewage manifested itself in less than 30 seconds and 90 per cent of the total chlorine demand of fresh

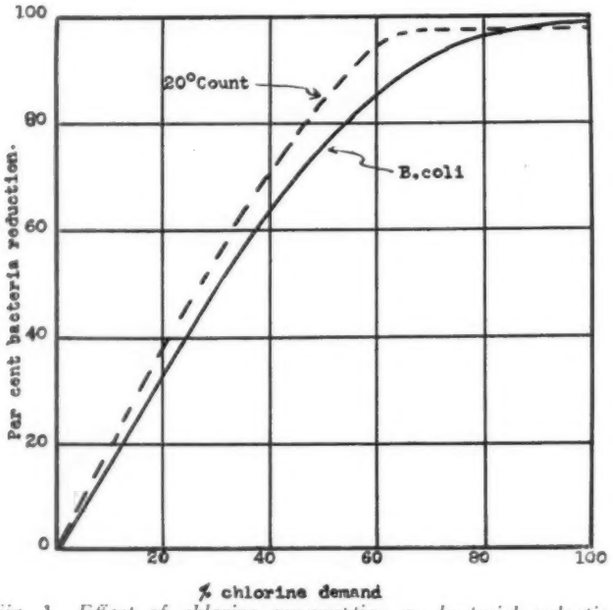


Fig. 1. Effect of chlorine consumption on bacterial reduction with constant contact time (7½ minutes)

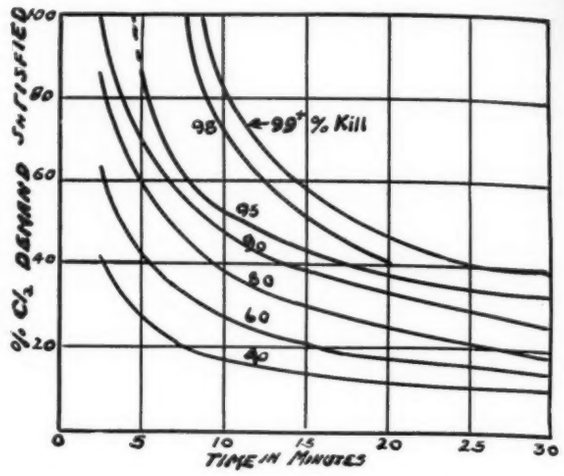


Fig. 2. Relation between chlorine demand satisfaction and contact time to secure definite percentages kill

sewage was felt in the same period. This is in accord with the findings of Hale, Enslow and Carpenter (4).

Since the rate of chlorine absorption does not vary materially with the sewage, whereas, the quantity required depends upon the character of the sewage, it appears that the chlorine added exerts its toxic effect immediately in the form of primary chlorine and thereafter in combination—as chlorinated organic products. The variations in the rate of chlorine absorption are due to the differences in quantities of products present which have a larger and more instantaneous demand for chlorine than has the mass of the material. It follows, therefore, that the velocity of kill should decrease with the increasing quantity of interfering substances. The effect of the chloro-products formed upon bacterial kill depends in turn upon the type of substances reacting with the chlorine. If these substances are undecomposed proteins there will be no additional reduction after the first immediate kill. When the materials are intermediate decomposition products (amino acids, amines, etc.) the secondary kill will be increased depending upon the length of time these chloro-products are in contact with the sewage. In other words, the longer the contact time the greater the kill, because these chloro-products act slower than does primary chlorine. If large quantities of ammonia are present the after-effect will be relatively quicker (greater) than with the other organic chloro-products.

Since a high percentage of the applied chlorine is absorbed immediately and most of the kill is almost instantaneous, it follows that the efficiency of the initial distribution of the chlorine is one of, if not the most important factor in procuring efficient and economical results in sewage chlorination practices.

Effect of Chlorine Demand Variations

From the results obtained it is obvious that partial chlorination, employing a fixed chlorine dosage, may be practiced. Since the immediate efficient distribution of the chlorine is more important than the contact time, the method of introduction of chlorine should be given the careful consideration it deserves. At many places the chlorine is mixed with a small stream of water and introduced through a single hose line into a large volume of sewage. The distribution of the chlorine is in such cases rather incomplete usually, and dependence must be placed upon longer contact time to allow the chloro-products to do the work. Methods of distribu-

tion by means of nozzles, forced sprays, etc., would undoubtedly save chlorine and allow the contact time to be reduced materially. This would be of especial importance where screened sewage is chlorinated in a sewer outfall before being discharged into bodies of water.

The advantage of rapid and thorough distribution, from the standpoint of saving chlorine, becomes less and less when the sewage is chlorinated to more than 50 per cent of its total chlorine demand. At the same time, if the sewage can be held for longer periods, so that the chloro-products are allowed to act, saving of chlorine can be practiced with success. Since stale sewage has a greater chlorine demand than fresh sewage, chlorine reduction can be practiced to greater advantage where stale sewage is treated by providing longer contact periods such as comes as the result of prechlorination —septic tanks excluded. The question of obtaining efficient results with less chlorine resolves itself, therefore, into a matter of procuring better initial distribution, longer contact periods, or both.

Practicing Partial Chlorination

Keeping in mind that initial distribution and contact periods are important in partial chlorination, this question arises where partial chlorination could be practiced with greater success. Assuming that 90 to 95 per cent B. coli reduction would be sufficient where large volumes of diluting water are available, the practicability of discharge of partially chlorinated sewage into the sea, bays, larger lakes and possibly some of the larger streams, comes at once to mind. In such instances efficient chlorine distribution should be available or else a sufficiently long contact time must be provided for. There are, without doubt, many places where screened sewage is chlorinated and where considerable improvement could be made by providing better chlorine distribution. In cases where no chlorine detention tanks are available good distribution in the trunk sewer should save considerable chlorine. With good distribution, sewage would need only to be chlorinated to 50 per cent or less of the chlorine demand to prevent odor production in sewers. (More detailed information on this phase of the problem will be published in the near future.) It is obvious that the many possibilities of securing better results and/or reducing the quantities of chlorine used to advantage will be apparent to those who are confronted with problems, the solution of which involves the use of chlorine.

In cases where more than 99 per cent kill is necessary, partial chlorination may still be practiced. The question of initial distribution and/or sufficient contact time in such cases becomes increasingly important and fixed partial chlorination will undoubtedly require good supervision. The suggestion made by Tiedeman some years ago to the effect that chlorine could be saved and efficiencies unimpaired by varying the chlorine dosage with the varying chlorine demand may be still further improved upon in some cases by practicing partial chlorination. The flexibility of chlorination would seem to be sufficiently indicated to be put to good effect by those interested in securing lower costs or better results at the same cost.

Further Work

It is the intention to publish as rapidly as possible the results obtained in sewage chlorination studies during the last two years. These studies deal with the effect of chlorine in reducing the 1 to 20 day B. O. D. effect on oxygen consumption, settleability of suspended solids, bacterial after-growths (types, numbers and time required), effect of split chlorination on chlorine demand and kill, effect of time on chlorine demand with complete and partial chlorination, effect of physical factors (such as temperature), effect of hydrogen sulfide on complete and partial chlorination and kill, effect of partial chlorination on H_2S production, and the effect of partial chlorination on the activated sludge process.*

*Note:—The effects of complete chlorination on activated sludge has already been published by Dr. Rudolfs in Water Works & Sewerage for September, 1934.—Ed.

REFERENCES

(1) Rudolfs and Ziemba, Jr. Bact. 4, 419, 1934.
(2) Rudolfs, Proc. N. J. Sew. Wks. Assoc. 3, 1934.
(3) Rudolfs, Ziemba and Gehm (in press).
(4) Hale, Enslow, Carpenter, Sew. Wks. Jr. 4, 252, 1932.

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Tenefly, N. J., Settles With Activated Sludge, Inc.

A Committee headed by Mayor Edw. Coleman of Tenefly, N. J., has settled with Activated Sludge, Inc., of Chicago, all claims made against the city for infringing the basic Activated Sludge Patents. Tenefly paid $2,024 and received full rights to use the activated sludge process and considers itself fortunate that it could be settled for the nominal sum instead of the $13,000 originally asked by Activated Sludge, Inc.

The suit was filed in 1933 along with some 120 similar suits against as many municipalities held to have infringed the patents by using the Activated Sludge process. Others having fought the suits have not fared so fortunately and it is reported that Woonsocket, R. I., had to pay $6,000 after having gone to the expense of a court case.

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Chemical Engineer's Handbook (A Review)

Edited by John H. Perry, Ph.D., and W. S. Calcott, Ch.E.. 2,624 pages (4½x7 inch). Publishers: McGraw-Hill Book Company, N. Y. C. Price $9.00.

Chemical Engineer's Handbook, a reference book of chemical engineering, has been compiled by Dr. John H. Perry and W. S. Walcott, who have assembled the contributions of 60 specialists, who in turn had the assistance of 150 chemists and engineers. It is designed to serve the Chemical Engineer as other standard manuals have served other engineers for many years and is destined to fill a useful place in the rapidly advancing chemical engineering field. Its wide range of subject matter, covering 2,624 pages, makes it of value also to mechanical, hydraulic and electrical engineers—the composite needs being that of the chemical engineer.

The 30 sections, each in itself a compact handbook on the topic dealt with, cover the following and other subjects: Physical-Chemical Properties and Calculations; Flow of Fluids and Heat; Evaporation; Humidification; Drying; Refrigeration; Cooling Towers and Ponds; Gas Absorption; Mechanical Separation; Mixing; Construction Materials; Transportation; Fuel; Power; Electro Chemistry; Cost Accounting; Report Writing; Patents and Patent Law; Numerous Conversion Tables of Weights, Measures and Constants; Short Cuts in Mathematics; Bibliographies.

An adequate review of such a voluminous but, at the same time, compact reference work is impossible in the space available. Its free examination offered by the publisher prior to purchase, and the heretofore published reviews of individuals sections by authorities, indicates the value of this new handbook in the engineering field—mechanical, electrical and chemical.

CANNERY WASTE TREATMENT IN WISCONSIN

A Review of Developments and Progress to Date

By L. F. WARRICK

State Sanitary Engineer,
Wisconsin State Board of Health

CANNING in recent years has expanded rapidly into one of this country's major industries. This development has created many problems for the canners to solve, not the least important of which is the utilization or inoffensive disposal of solid and liquid wastes produced in various canning processes.

Because many cannery wastes are much stronger than equal volumes of ordinary domestic sewage, and also frequently differ from sewage in chemical and other characteristics, discharge of these wastes untreated into public sewerage systems has caused difficulty at municipal sewage treatment works. Cannery wastes emptied direct into water-courses have given rise to an increasing demand by the public for proper treatment of canning plant wastes.[1]

Experiments in cannery waste treatment have been conducted in several states, and considerable information and data of value in the solution of problems presented by the various canning wastes have been obtained through these recent investigations. Special attention is called to comprehensive studies conducted by the U. S. Public Health Service[2]; in Ohio[3]; New York[3, 4]; Indiana[3], and Michigan[5]. As a contribution to the information concerning this subject, it is the purpose of this paper to briefly outline results of cannery waste treatment studies and the progress made in Wisconsin on a practical basis to date.

Co-operative Studies

During 1925 a co-operative waste treatment research program was proposed to the Wisconsin Canners Association by the Wisconsin State Board of Health. It was pointed out that satisfactory methods of treating cannery wastes had not yet been developed; and, that, while this was the problem of the industry, the state would co-operate in developing such methods. Since pea cannery wastes offer the major problem in Wisconsin, it was suggested that preliminary activities be confined to the development of practical and economical means of treating these wastes. An appropriation of $500.00 was made by the Wisconsin Canners Association to start the work, and the results of the preliminary studies conducted at Poynette, Wisconsin, during the 1926 canning season have been published in a report, "Stream Pollution in Wisconsin,"[6] copies of which may be obtained from the State Board of Health.

In brief, the initial work indicated that the pollutional substances in pea canning wastes could be reduced 75 per cent (on the basis of oxygen demand) by fine screening and chemical treatment, using 3¼ pounds of ferrous sulphate and 7¼ pounds of hydrated lime per 1,000 gallons, with thorough mixing and a settling period of at least one hour. Daily removal of the sludge was found essential to maintain this treatment efficiency and to permit rapid drying on sand beds without any odors. Analyses of the sludge showed a fertilizing value of $3.50 per ton of dried material, sufficient to warrant removal to nearby farms. Treatment costs for a two-line cannery were estimated at from $13 to $15 per day at full capacity operation of the cannery. Chemical treatment of pea cannery wastes without removal of the coagulated organic solids prior to discharge to municipal sewers, does not materially lighten the load imposed on municipal sewage treatment plants.[7]

Wastes receiving treatment included (1) blancher effluent—resembling pea soup, (2) produce washings before and after blanching, and (3) floor and equipment washings. Silage juice produced by fermentation of stacked pea vines was disposed of by soil absorption at viner stations on nearby farms. Water used to cool the canned peas was by-passed and used to dilute the treated effluent. Domestic sewage from toilets and lavatories was disposed of separately by means of a septic tank. The volume of waste amounted to about one gallon for each No. 2 size can of peas packed.

Plant Design and Operation

The results of the preliminary studies were used in the design and installation of waste treatment plants during 1927 at pea canneries where very unsatisfactory conditions existed. The plants were of two general types, classified as (1) continuous flow and (2) fill and draw systems, depending on the method of handling the wastes. Operating experiences with seven treatment plants indicated that the fill and draw system, such as shown in Fig. 1, gave more satisfactory results, due largely to more exact and greater ease in the control of treatment and better facilities for sludge removal.[7] Though, in gen-

Fig. 1—Typical fill and draw type of chemical treatment plant for cannery wastes. Must have at least two settling tanks.

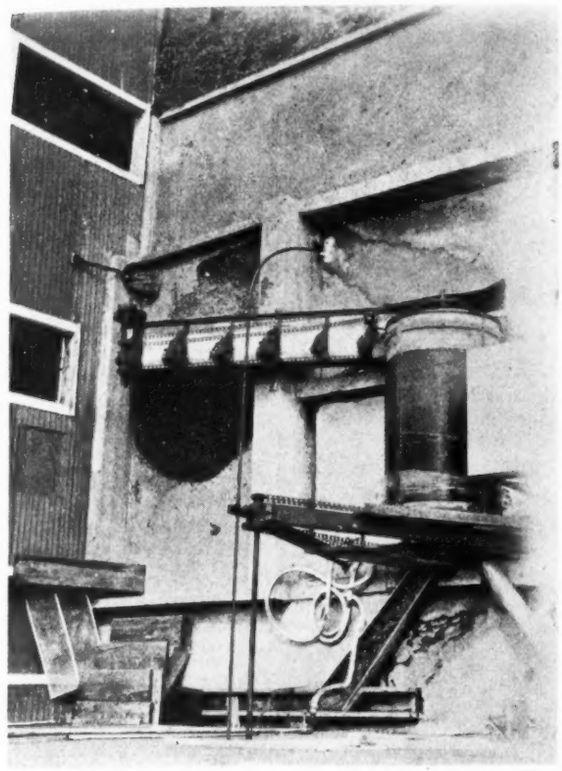

Fig. 2—Fine screening of cannery wastes through 40-mesh wire is the first and an essential step in treatment.

eral, the results obtained were satisfactory, they definitely indicated the need of minor modifications in design and operation control methods, the desirability of secondary treatment in some cases, and a better understanding of plant operation by the canners. Construction of continuous flow plants has since been discontinued for reasons later cited.

Screening Is Essential

Screening of the wastes is the first step in the removal of organic substances, and is necessary irrespective of the method adopted for further treatment. Experience has indicated that most effective results are obtained with mechanical rotary screen units having at least a 40 mesh wire covering. These units should be provided with satisfactory discharge facilities for materials removed from the waste, such as shown in Fig. 2. An ideal installation for the removal of screenings consists of a perforated bucket elevator and a storage hopper located high enough to permit the contents of the hopper to be dumped into wagons or trucks and hauled to nearby farms for stock feeding purposes. Because of the improvements effected at relatively little cost for installation and operation, all canning plants should be provided with efficient screening equipment.

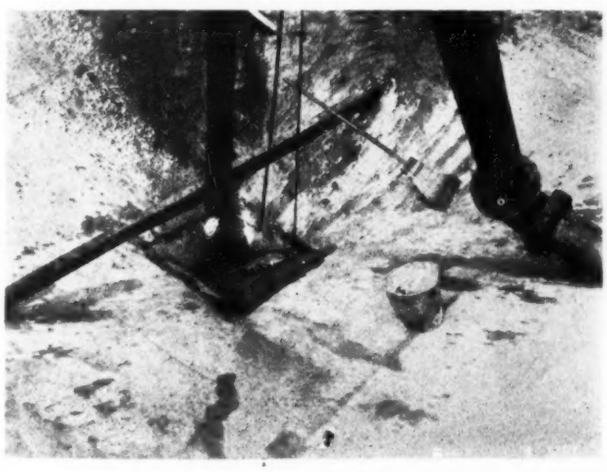

Fig. 4—One of the hopper bottoms of the fill and draw type of chemical treatment plant. Note the quick opening gate valve for drawing off sludge, the motor boat propeller used for the secondary gentle flocculation of the wastes. The swivel outlet pipe, shown on the right, lowers gradually to draw off clear liquor from the surface after settling is sufficiently advanced.

In certain situations the canners decided to try broad irrigation or lagooning of the screened wastes in sand and gravel pits at relatively isolated sites, controlling odor nuisances by the application of chlorine and lime. Experiences indicated that these soil absorption methods are limited in application to areas where the wastes will rapidly seep away, and where odors will not create a nuisance. Chlorination was found to have limited effectiveness in controlling odors in disposal by soil absorption.

Chemical Precipitation—Results and Costs

During the summer of 1928, studies were made of the operation of thirteen plants treating cannery wastes.[8] Eleven of these used the principle of chemical precipitation, and two disposed of the wastes by broad irrigation. Operating results indicated that by the use of the chemical treatment plants the objectionable organic substances in the wastes, as measured by the oxygen demand, were reduced from 50 to 75 per cent by application of 3¼ pounds of ferrous sulphate (copperas) and 7¼ pounds of lime per 1,000 gallons of pea canning wastes; 2¼ pounds of ferrous sulphate and 6.0 pounds of lime per 1,000 gallons of wax bean wastes; and 3¼ pounds of ferrous sulphate and 6.0 pounds of lime per 1,000 gallons of corn wastes. Experience showed that thorough mixing of the chemicals with the waste and a settling period of at least one hour are required to insure proper treatment; and, daily removal of the sludge is essential.

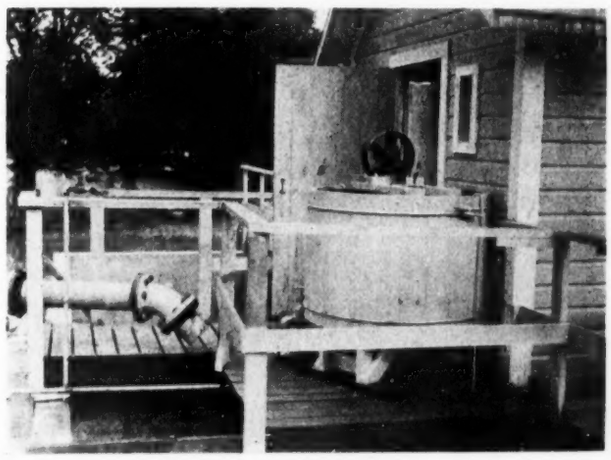

Fig. 3—Lime emulsion tank provided with an agitator. Note the swivel waste inlet pipe at the left providing violent mixing during the tank fill.

Treatment of pea wastes was accomplished at a cost of 34 to 78 cents per case of No. 2 cans of peas, which figure includes cost of chemicals, labor, and disposal of the sludge. The higher cost per case was for the smaller plants, since labor costs were about the same for all installations. The cost of a treatment plant, properly designed, constructed and equipped for the treatment of wastes from a three line pea cannery, was $3,500.00.

Some of the modifications made in the design and construction of the fill and draw treatment plants include circular tanks with conical bottoms having a 45 deg. slope, lime solution tanks as shown in Fig. 3, quick opening gate valves to facilitate sludge removal, and other changes in mechanical equipment to aid the plant operator. The interior of one of the fill and draw treatment tanks is shown in Fig. 4. The sludge bed units were increased to 12x16 feet in plan with 18 inch walls above the sand, and were provided with swivel pipes for removal of clear liquid from the surface of the sludge to allow more rapid drying. About 6 inches of washed sand placed over 6 inches of graded gravel, on a 4 inch drain tile, was found to be the most satisfactory construction for sludge beds. Usually one of these drying beds is required each day for the sludge produced by a two line pea cannery.

Construction of continuous flow treatment plants has been discontinued in view of difficulties encountered in operation. Adjustment of chemical dosages to meet variations in volume and strength of the wastes, the control of mixing and coagulation, and the complete removal of sludge daily was found to be accomplished most effectively by means of the fill and draw system. Should the continuous flow system be used, it is considered most essential that mechanical facilities be provided for positive removal of the sludge.

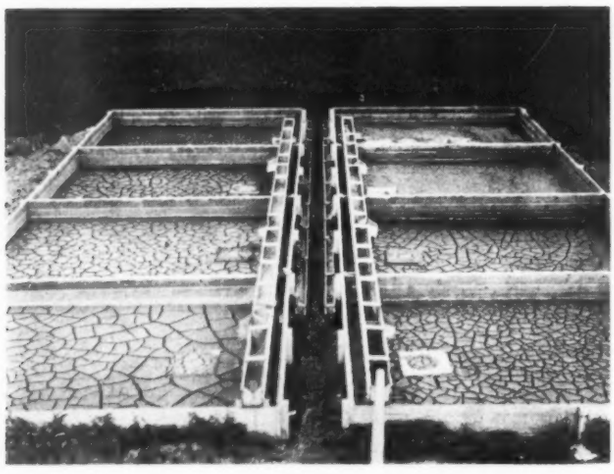

Fig. 6—Drying beds for solids removed in the chemical treatment process. With proper pH control the sludge dries rapidly with no offensive odors; is removable after 4 to 7 days.

Sludge Removal Important

In the early work at Poynette[6] it was observed that sludge left in contact with the treated wastes would start decomposition within two days, the clarified wastes would rapidly become acid and become turbid, and the precipitated sludge would partially go back into solution. Studies have indicated that when all sludge was not drawn off, the efficiency of treatment, on the basis of oxygen demand, would be reduced about one-half.

The tests reported in Table I were made on a continuous flow system, the tank of which had been emptied and thoroughly cleaned just before the first run was started. Sludge was pumped to drying beds daily, but all of the chemically precipitated solids could not be removed. The data are based upon complete treatment records and analyses of composite samples of wastes, covering a full day of pea canning plant operation, made according to standard methods.[9]

It will be noted in Table I that after the first two days the treatment efficiencies, as shown by reductions in oxygen consumed and oxygen demand values, began to decrease and continued to do so throughout the following runs. The last run was "sour" sludge indicated about one-half as effective treatment as obtained initially with the clean tank. Lime dosages were increased to offset acid conditions developing through decomposition of the accumulated organic material. It became necessary as the work progressed to add lime directly to the tank contents, particularly at the start of the day's run, to minimize gassing and resulting interference with settling of solids.

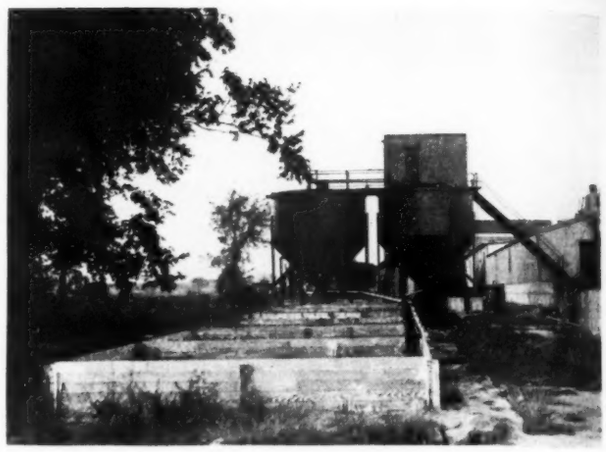

Fig. 5—Welded steel tanks have recently been built by some canneries in place of the usual square or circular concrete chemical precipitation tanks. Note the steep conical bottoms productive of dense sludge.

Such conditions can be entirely prevented with the fill and draw treatment plants. With such plants it is possible to discharge the sludge (concentrated in hopper bottomed tanks shown in Fig. 5) direct to the drying beds before any decomposition starts. Separation of the clarified wastes and sludge is followed by rapid dewatering on the drying beds, through underdrains and by use of swivel decant pipes for removal of the clear liquid appearing on top of the sludge in the beds. Assuming that the treatment applied has been correct, the pH of the sludge should be 9.8 or greater. In this condition it can usually be dewatered fast enough to expose the solids to the air within four hours. It will start "cracking" in 24 hours and be sufficiently dried to permit removal from the beds in from four days to a week. Fig. 6 shows sludge, produced with proper treatment, in various stages of drying. Cracking shown can be controlled by

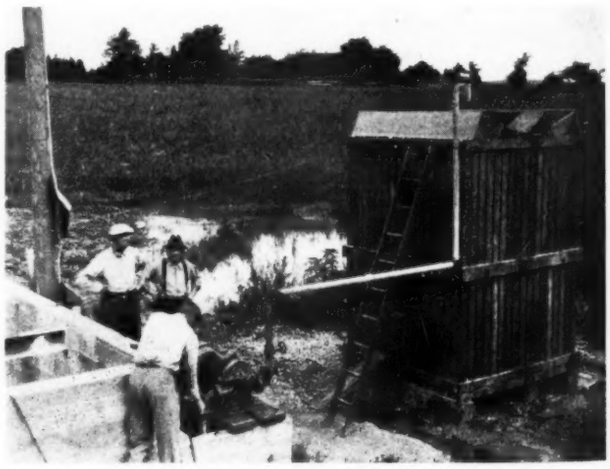

Fig. 7—Bio-oxidation process of treatment for cannery wastes using a trickling filter to oxidize precipitation tank effluent or fine screened waste if required.

scoring the surface of the sludge as soon as the "free" water has drained away. Drying and handling of such sludge is accomplished without production of offensive odors.[10]

Trickling Filter Studies

Studies of treatment of pea cannery wastes by use of a trickling filter, both with and without chemical precipitation in advance of filtration, were started in 1928. Information was sought on the effectiveness of trickling filters as a secondary treatment process to be used under conditions where little or no dilution other than cooling water is available for the final effluent.

An experimental trickling filter unit, shown in Fig. 7, was constructed at a cannery provided with a continuous flow type chemical treatment system. This unit was built of crushed rock 1 to 1½ inch in size, placed in a wood frame or crib, 6x6x8 feet deep, and provided with tipping trough dosing facilities. Facilities were installed for pumping the chemical precipitation tank effluent or the screened wastes to the filter unit. Completed just prior to the pea canning season, the filter was placed in operation and kept in service throughout most of the pea pack. The initial studies indicated that the trickling filter would reduce the remaining oxygen demand of the pea wastes, after chemical treatment, from 35 to 84 per cent if the volume of the wastes applied was kept below a dosage rate of three million gallons per acre of filter area per day—hereafter noted as m.g.a.d. About two weeks of operation was required before the filter became effective.

Studies of the time required for the treatment efficiency of the filter to build up after the start of the pea pack were continued in 1929. The filter was dosed at a 2 m.g.a.d. rate, an average operating day of 15 hours. An attempt at seeding the filter was made by passing a manure infusion through the unit for several days in advance of the start of canning. Results of analyses made twelve days after beginning of the pea pack showed an efficiency of 58 per cent (as indicated by reduction in oxygen consumed value), while after fourteen days the efficiency on the same basis was 88 per cent. No B.O.D. data were secured on the 12th day, but the test at the end of two weeks' operation showed a reduction in 5 day B.O.D., from 750 to 125 p.p.m.—or 83 per cent. With a filter dosage rate of 3 m.g.a.d., after 19 days had elapsed the 5 day B.O.D. was decreased from 1550 to 480 p.p.m., or 69 per cent, and the oxygen consumed values from 1730 to 416 p.p.m., or 76 per cent. From this and other data it would seem that with seeding by a manure infusion for five days in advance of the canning season, from 10 to 14 days are required after the start of the pea pack to reach a fair operating efficiency.

Since the pea canning season lasts only about six weeks, another method of seeding the filter was tried prior to the 1930 pack. The material sloughing off the rock of trickling filters at a municipal sewage treatment plant was obtained and applied to the experimental filter twice daily for four successive days, starting one week prior to the pack. The filter was wetted at least twice each day; a sugar solution, 8 pounds of cane sugar per day, being used in an effort to build up a suitable biological growth on the filter rock. The second day of the pea pack, after the filter had been in service a total of five hours, a run was made using a dosage rate of 1.5 m.g.a.d. Analyses showed a reduction in the oxygen consumed values from 1760 to 420 p.p.m, or 76 per cent. Fifteen days after this initial run the reduction at about the same dosage rate (1.6 m.g.a.d.) was from 1600 to 120 p.p.m., or 94 per cent for oxygen consumed; and, was from 1600

TABLE I.—DATA SHOWING RESULTS OF PEA CANNERY WASTE TREATMENT WITH CONTINUOUS FLOW TYPE CHEMICAL PRECIPITATION PLANT FOLLOWED BY A TRICKLING FILTER*

Run No.	Chemical Dosage in lbs. per 1000 gal. Ferrous Sulphate	Lime	Filter Dosage Rate**	pH Raw Wastes	pH Chem. Tr.	pH Filter Eff.	Turbidity in p.p.m. Raw Wastes	Turbidity in p.p.m. Chem. Tr.	Turbidity in p.p.m. Filter Eff.	Oxygen Consumed in p.p.m. Raw Wastes	Oxygen Consumed in p.p.m. Chem. Tr.	Oxygen Consumed in p.p.m. Filter Eff.	5-day B.O.D. in p.p.m. Raw Waste	5-day B.O.D. in p.p.m. Chem. Tr	5-day B.O.D. in p.p.m. Filter Eff.	Efficiencies in Per Cent—By Chemical Treatment Oxy. Con. %	By Chemical Treatment 5-day B.O.D. %	By Trickling Filter Oxy. Con. %	By Trickling Filter 5-day B.O.D. %	Overall Efficiencies Oxy. Con. %	Overall Efficiencies 5-day B.O.D. %
				Treatment with Chemicals and Filter																	
1	2.73	9.56	2.6	6.8	9.8+	8.2	265	65	60	3200	1160	130	2840	1030	85	62	64	89	92	96	97
2	2.3	9.9	2.6	6.9	9.8+	8.0	270	65	70	2840	1150	120	2600	950	100	60	63	90	89	96	96
3	2.2	10.2	1.6	7.0	9.8+	7.9	280	110	75	3400	1760	100	3800	1600	120	48	58	94	92	97	97
4	1.9	9.6	2.1	6.9	9.8+	8.0	300	60	90	2400	1040	120	2200	1330	390	56	45	88	71	95	82
5	2.2	11.3	4.7	6.8	9.8+	8.1	300	45	80	2320	1160	420	2250	1185	505	50	46	64	58	82	78
6	2.3	12.2	3.6	6.8	9.8+	8.1	320	95	80	3400	1660	580	3000	1640	625	51	46	66	62	83	79
7	1.6	11.1	3.3	6.7	9.8+	8.1	340	60	110	3220	2020	555	3150	1950	620	38	38	66	60	83	80
8	1.6	11.1	2.4	6.9	9.6	8.0	340	70	110	3900	2500	590	4200	2550	780	36	34	76	70	85	81
				Treatment with Screen and Filter Only																	
9	..	..	1.0	6.8	..	8.0	310	..	160	3840	....	560	4500	....	675	..	..	86	85	..	..
10	..	..	1.4	6.7	..	8.1	330	..	180	3320	....	820	3375	....	1080	..	..	75	70	..	..
11	..	..	2.1	7.0	..	7.8	260	..	150	2520	....	670	2350	....	630	..	..	73	73	..	..
12	..	..	10.0	6.8	..	7.2	330	..	160	2540	....	1270	2500	....	1330	..	..	50	47	..	..

*Tests made by J. A. Reid, formerly Assistant Chemist, Bureau of Sanitary Engineering, Wisconsin State Board of Health.
**Filter dosage rate in million gallons per acre per day. Filter 8 ft. deep.

to 120 p.p.m., or 92 per cent, for 5 day B.O.D. The data and observations indicated that by the use of the seeding procedure outlined the treatment efficiency of a trickling filter may be, in large part, established before canning starts.

Data obtained in a series of runs made with this experimental filter unit (Fig. 7) are set forth in Table I. The series was started two weeks after the beginning of the pea pack and carried out over the remainder of the pea canning period. It will be noted that very good treatment results were obtained with the filter receiving chemical treatment plant effluent at dosage rates under 3 m.g.a.d. The same observation applies to the pea wastes after screening only, and with dosage rates of from 1 to 2.1 m.g.a.d. While a surprisingly good efficiency is shown for the 10 m.g.a.d. rate (Table I), it needs to be pointed out that this run was made only over a few hours after the filter had been in service a month to see if serious ponding would occur. Since it appeared that additional solids discharged on the filter when wastes pre-treated by screening only were applied were tending to clog the unit, it is believed that this rate could not be maintained very long without serious ponding and a materially lower efficiency than indicated above. The run does indicate the possibility of a filter producing fairly good results when greatly overloaded for brief periods. It is interesting to note that the filter efficiency was not hurt by application of precipitation tank effluent pH values of 9.8 and somewhat higher.

Secondary Treatment With Municipal Sewage

Results of the trickling filter studies were used as the basis of a plan for secondary treatment of sewage recently carried out in a Wisconsin municipality, whereby wastes from a cannery (after chemical treatment) are discharged into the dosing tank of the new trickling filter at the city plant. From results obtained to date this arrangement has been successful in alleviating a very serious pollution problem.

The discharge of the cannery waste by separate pipe line into the dosing tank of a trickling filter at a municipal plant is unnecessary, if an ample detention period is available in the primary tanks, and provided that sufficient filter capacity for the combination of chemically treated cannery wastes and the domestic sewage is available. This has been shown by operating results obtained in another Wisconsin city.

Studies during the summer of 1934 have been directed toward determining whether pea and corn canning wastes, after fine screening, can be mixed with domestic sewage in a city of about 6,000 population, and be efficiently treated in an activated sludge plant.[11]

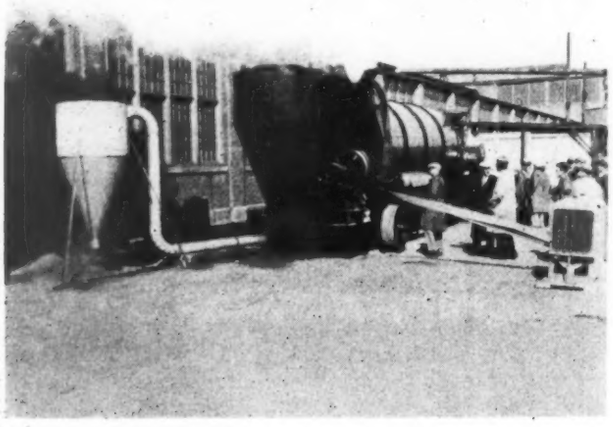

Fig. 9—Pea vine dryer in operation. Production of stock feed thereby is one solution to the vine juice (silage juice) problem.

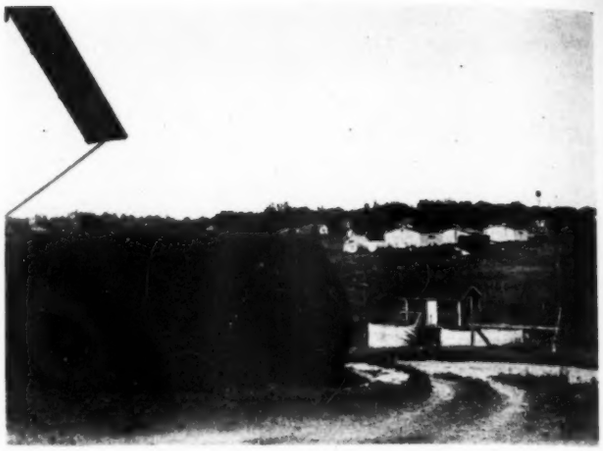

Fig. 8—Such stacks of pea vines as shown in the picture are often the source of fly and odor nuisances. Disposal of the juices from such stacks is now the major problem to be solved.

In all such cases it is only fair that the canneries bear a fair portion of the additional installation and operation costs involved in the treatment and disposal of the combined sewage and wastes. The enactment of laws whereby sewer service or rental charges may be made upon some equitable basis makes it increasingly possible to work out satisfactory solutions of these co-operative problems.

Elimination or Disposal of Silage Juice

Progress is steadily being made in abating nuisances and stream pollution caused by cannery wastes. Development work includes many special projects, such as the elimination of silage juice seeping from pea vine stacks, like that shown in Fig. 8, by cutting and drying the vines as they leave the viner station. A new type of drier suitable for this purpose was invented in Wisconsin several years ago, and is now being manufactured and sold in both stationary and portable forms. One of the portable driers is shown in Fig. 9. By use of such equipment the substances wasted in silage juice can be retained in the stock food produced.

Unless such drier facilities are provided it is necessary to haul or pump the silage juice to some isolated site for disposal by soil absorption. Fly and odor nuisances around the pea vine stack must be minimized by the application of lime and deodorants.

Operation and Research

Cannery waste treatment systems installed to date in Wisconsin include 34 plants of the chemical precipitation type. Operation has been systematized through establishment of routine pH control and precipitation tests. Daily records are kept covering essential information, copies of which have been filed with the Bureau of Sanitary Engineering of the State Board of Health. These results have been of material value in carrying forward the co-operative program.

To assist the canners in obtaining maximum operating efficiencies with the treatment plants, university students desiring summer employment at the canneries were given a preliminary instruction course in the waste treatment control methods prior to the start of the 1928 and subsequent canning seasons. Considerable credit for the excellent operation obtained and improvements made following adoption of this policy must be extended to these men and to chemists co-operatively employed by the Wiscon-

sin Canners Association, to assist the State in carrying out canning plant waste treatment activities.

Acknowledgment:—This presentation of developments in cannery waste treatment in Wisconsin would not be complete without mention of the valuable contributions to the success of the work brought about through studies of N. H. Sanborn, chemist, National Canners Association; A. P. Colburn, engineers, and B. Landow, chemist, employed by the Wisconsin Canners Association in co-operation with the Wisconsin State Board of Health and State Committee on Water Pollution; and J. P. Smith, W. U. Gallaher, engineers, and J. A. Reid, chemist, formerly with the Bureau of Sanitary Engineering, Wisconsin State Board of Health.

Much work remains to be accomplished both in applying present knowledge and in continuing the research to improve existing, and to develop new, facilities to permit still more efficient and economical utilization or treatment of canning plant wastes. It has been shown that this work can most advantageously be performed with the support and co-operation of the National Canners Association and the various State Canners Associations.

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An Inexpensive Odor Detector

By F. E. STUART*

The accompanying picture shows a very simple odor detector developed by the writer for evaluating the efficacy of Aqua Nuchar (activated carbon) in odor elimination from waters.

This odor detector is quite sensitive because two tubes are used to draw the odor to the nose; each functioning individually. The diameter of each tube is just sufficient for normal breathing. When smaller tubes are used or when restricted orifices are made in the top of the tubes, normal respiration is hindered and the ability to detect traces of odor is reduced.

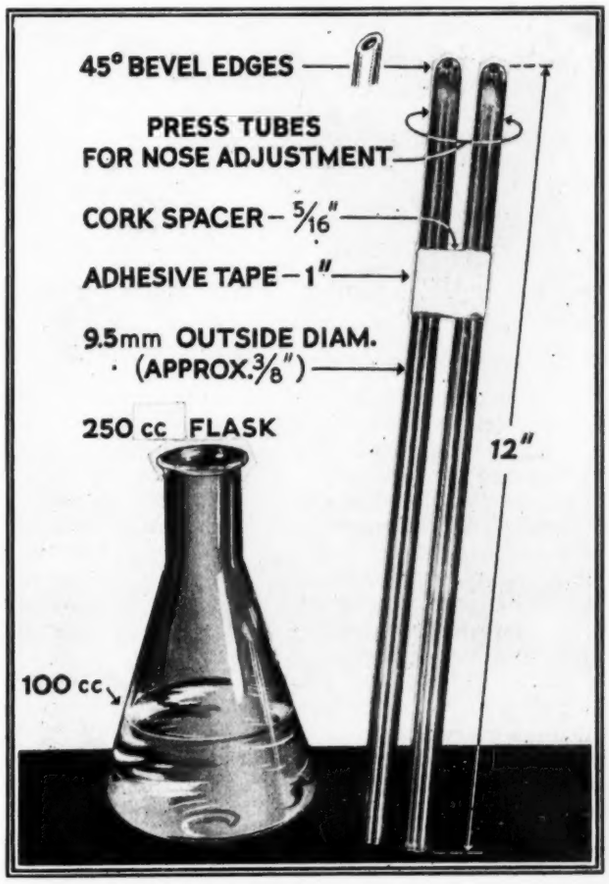
In making the odor detector, grind or file a bevel edge on two 12-inch lengths of glass tubing of 9.5 millimeter outside diameter. A small section of a cork stopper, approximately 1 inch long, is cut and shaped for spacing the tubes. About ¼ inch spacing is desired, which will give 5/16ths inch spacing at the top when the tubes are pressed together slightly at the bottom. Fasten with 1-inch adhesive tape wrapped around tubes and cork.

The cork is flexible and therefore gives an adjustable nose piece, by pressing the tips together. The cork spacer should be placed 3 inches from the top in order that the glass tubes will come together at the bottom, so the apparatus can be used in an ordinary 250 cc. Erlenmeyer Flask.

Making Odor Observations

Place 100 cc. of water in the flask. Hold flask in the right hand and the odor detector in the left hand. Place the odor detector to the nose gently and insert into the flask until approximately ½ inch from the water surface. Rotate or shake the flask slightly with the right hand to release the odor. Gentle sniffing at this point will produce an odor which cannot generally be detected at the mouth of the flask, due to the air dilution in the flask. Shaking or rotating the flask is very important because it liberates volatile odors in the water.

Through use of this simplified apparatus very slight odors can be detected in warm water, which would later give taste and odor troubles in the distribution system. The test is equivalent to nothing less than an extension of the nostrils into the flask. The effect is very similar to that procurable if breathing while under the shower of the water, such as is gotten in shower baths. The detector is so simple to make that each observer can have an odor detector for his own individual use.



Odor Detector

*Water Purification Div., Industrial Chemical Sales Co., New York City.

A STUDY OF FILTERING MATERIALS FOR RAPID SAND FILTERS

Part 3: Various Kinds of Filtering Materials*

By JOHN R. BAYLIS†

Physical Chemist, Dept. of Public Works, Chicago

John R. Baylis

A NEW method of determining the effective size of filter sand for rapid sand filters, and the effect of the size upon the lengths of filter runs, were discussed in Part 2* of this series. The data and discussion applied to filter sands generally used in rapid sand filtration plants throughout the country, in which the material is fairly rounded. The occasional use of crushed materials and materials other than silica sand makes it desirable to give some consideration in this article to such materials and to their shape.

It is known that crushed materials such as crushed quartz and crushed anthracite coal are angular in shape and when used for filter beds the openings through the bed (spaces between grains) will be somewhat larger than those through beds of rounded material for the same size granules. Determining the sand size is an indirect method of determining the openings through a bed of the material. When filtering materials do not vary materially in shape, a variation in the diameter of the particles gives indication of the resulting variation in the openings through the filter bed. If only rounded materials were used it might not be necessary to determine, directly, the size of the openings in order to compare materials, but since angular materials have been introduced for filter beds it becomes necessary to take the size of the openings or porosity into consideration.

Equipment and Materials Used in Tests

In addition to ordinary filter sand, experiments have been conducted and tests run on crushed anthracite coal, crushed quartz, crushed glass, granular cocoanut char, Minchar, iron ore, and slag.

Anthracite Coal.—Anthracite coal from two sources was used. One shipment of material came from the Water Department of Denver, Colorado, and was the same as the material used in the Denver filters. Another shipment of material came from the Anthracite Institute. The latter material came just as it was after crushing and the fine and coarse material had to be sieved out. The material from the Denver Filtration Plant had been prepared ready for use in filter beds and did not need to be graded.

Crushed Quartz.—The crushed quartz was obtained from Copley, Ohio. It also contained some fine material which had to be sieved out before use. The material was very hard and the composition probably is the same or approximately the same as that of much of the silica sand found throughout the country.

Minchar.—Minchar is a product manufactured for use in removing objectionable tastes and odors from water. It is produced by burning a certain form of clay or marl mined near Elmira, New York, and contains 6 to 8 per cent of carbon after burning. The granules, even though porous, are fairly hard. The particular material used was a sample which had been sent to us for experiments on taste and odor removal. As it had been sieved already, it was used as received, after removing the coarsest grains.

Crushed Glass.—The crushed glass was prepared by crushing broken glass bottles. This gave a fairly large number of particles in which part of the surface was the original outside smooth, flat surface of the molten glass.

Cocoanut Char.—The cocoanut char was granular activated carbon made from cocoanut shells. It is a very porous and fairly light material, though the granules are heavy enough not to float when the pores have become filled with water. The main reason for using such a material was to have included a material with granules of very low specific gravity.

Crushed Slag.—Slag from an iron furnace was crushed and sieved to give the proper sizes. So much calcium salts were leached out that it caused the granules to stick together and could not be used for filtering purposes.

Iron Ore.—There is considerable doubt as to the form in which the iron occurred in this material. The stones which were crushed to make the material came from Northern Michigan and had a black appearance. The material varied considerably in hardness and it is probable that there was some variation in the specific gravity of the granules, because the distribution of the iron in the material did not appear to be uniform. It was used because it had a specific gravity higher than that of ordinary sand.

Sand.—The sands used in the shape tests were obtained from Ottawa, Illinois, and Muscatine, Iowa. The Ottawa sand is fairly rounded and the Muscatine sand is sometimes classified as a sub-angular material. Both are materials used to a considerable extent in filtration plants.

Size of Materials.—Samples of each of the materials used were sieved in accordance with the usual method of sieving sand, and the effective sizes determined by the new procedure given in Part 2. Table 5 shows sieve analyses of the materials used. In most instances the effective size was determined from the sieve analysis of a representative sample of the material. There were several cases, however, where it was thought best to sieve the top material after the bed had been washed. This was because the material was not stratifying very well according to size.

Filters.—Glass tube units were used for the filters. For details as to how the filters were set up see Part 2.

†Associate Editor, WATER WORKS AND SEWERAGE.

*This is one of a series of articles by Mr. Baylis dealing with "Filtering Materials for Rapid Sand Filters." Part 2 appeared in the May issue and Part 1 in the April issue. The next in this series will appear in the November issue.—*Editor.*

TABLE 5.—SIEVE ANALYSES OF MATERIALS USED IN SHAPE TESTS.

Filter	Material	—% by Weight Passing the Sieve— 16	20	24	30	40	50	60	Effective Size mm.
JX-3	Ottawa sand...	100.0	99.3	86.8	17.4	.9	.2		.503
DX-2	Muscatine sand.	100.0	96.5	69.3	17.3	1.8	.2		.489
EX-3	Crushed quartz.	100.0	95.9	72.0	20.5	2.9	.2		.475
HX-3	Anthracite coal.	100.0	94.9	69.3	19.7	3.4	.4		.450
Z-4	Crushed glass..	100.0	99.1	57.6	14.9	3.5	.7		.432
FX-4	Minchar	100.0	100.0	71.3	20.3	.4	.2		.519
GX-3	Cocoanut char..	100.0	93.7	75.8	15.7	.4	.4		.515
D-5	Crushed slag...	100.0	97.2	61.4	20.5	2.8	.1		.460
D-7	Crushed iron ore.	100 0	99.6	63.6	32.2	15.2	3.6	.73	.331
D-1	Muscatine sand.	99.9	94.8	62.5	14.8	1.93	.9		.444
J-3	Anthracite coal (top 6 inches).	91.4	50.7	20.8	4.56	1.25			.617
EX-2	Crushed glass (16 inch bed)..	54.8	33.7	17.2	4.4	1.9	.1		.515

The depth of the bed of filtering material in most of the filters was 24 inches. The beds were supported by about 6 inches of graded gravel.

Equation for Computing Filter Runs.—The equation for determining the effect of size upon the lengths of filter runs given in Part 2 is

$$(1) \qquad H = K D^{2.15}$$

H = Hours filter runs (obtained from actual filter runs).

K = Filtration constant.

D = Diameter of the effective size of the material in millimeters.

It was stated (Part 2) that the filtration constant must be determined from actual tests, and that there is no means at present of even approximating the value of "K" by computation. The figure given for the power of the diameter is based upon a filtration rate of 2 gallons per square foot per minute. This equation may be used only when the materials are approximately the same shape and have approximately the same porosity. When materials more angular than natural sands are used, the openings through the beds are larger for grains of a given size (determined by sieves) and consequently will give longer filter runs. Our experiments, covering only a limited range in porosity, indicate that the runs vary as the 2.13 power of the percentage porosity. The equation for computing filter runs, where materials which vary in porosity are being compared, may be expressed as follows:

$$(2) \qquad H_1 = \frac{K (D_1^{2.15}) (P_1^{2.13})}{P^{2.13}}$$

H_1 = Filter runs in hours on filter with a porosity of P_1.

K = Filtration constant, determined from actual filter runs.

D_1 = Effective size in mm. of the filtering material having a porosity of P_1.

P_1 = Porosity of material on which the filter run is to be computed.

P = Porosity of material where the length of filter run is known.

It is not known that the 2.13 power of the porosity is an exact figure. Data collected from many sources will be required before the exact figure can be determined. It may vary between the square of the percentage porosity and the 2.5 power, but it is believed to approximate the 2.13 power. In fact, it may be a figure which varies lightly for differences in character of waters.

Equations for the Flow of Water Through Sand Not Applicable to Filter Performance.—The writer has been asked so often, whether the equations recently developed by Hulbert and Feben, and by Fair and Hatch, may be used for computing filter performance, that it is believed a very brief discussion of these equations should be made. They are satisfactory for computing the initial loss of head—that is, the flow of clean water through sand—but, it is believed they have no application to practical filter performance. Most of the factors in these equations, such as size of openings through the sand, rate of flow, and temperature, will have to be taken into consideration in computing filter performance if an equation is ever developed, but it seems certain that some of the factors used for computing the flow of water through sand will have to be modified for use in an equation for computing filter performance.

Examination of the porosity factors used in the equations for flow of water through sand will show that they are not fundamental for filtration, though they may be fundamental for the flow of water through sand. It might be well to state that the authors of the equations mentioned have not claimed that they apply in computing filter performance. There are a number of water purification workers, however, who believe that such equations are going to lead to an equation for computing filter performance merely by the addition of one or two more factors. It is not likely that these equations will be of any value in computing filter performance and it is believed they are limited solely to computing the initial loss of head, something which we already know within limits accurate enough for practical purposes.

Take the porosity factor of the Fair and Hatch equation, for example. It gives an infinite value for 100 per cent porosity, which is correct for the flow of water through sand. This, however, is not correct for filtration, because, as the porosity becomes more and more, a definite limit in the area of the opening is approached. Assume that spherical sand grains .5 mm. diameter were packed in a regular manner with each grain directly above the grain below. The porosity is 47.6 per cent. Now assume that these spheres are held in this position and the solid material gradually taken away except in a line from the center of a sphere to the center of the 6 spheres which it touches. The limit of the area of the opening is a square with sides 0.5 mm. Naturally this size opening will give much more area for the accumulation of the suspended matter removed from the water, but filtration will take place and an infinite value in the length of filter run is not being approached. It is easy to see that the Fair and Hatch equation cannot be used for filtration, even though it has a shape factor which tends to throw the results a little more in line by reducing the porosity effect. The Hulbert and Feben equation is still more out of line in that their porosity factor gives an infinite value before the porosity reaches 100 per cent.

Development of a Theoretical Equation for Computing Filter Performance Does Not Seem Possible at the Present Time.—It may be digressing from the subject to discuss at length equations for filter performance, but it is essential to have some means of comparing filtering materials. It is believed that the best we can do at the present time is to determine how one kind of filtering material may be compared with another, when the filter runs on any one kind of material are known. In equation 2 it is assumed that the rate of filtration is constant. The temperature is not taken into consideration in equations 1 and 2. This is not essential for comparing materials, though it would be necessary in an equation for computing filter performance. The clogging tendency of the coagulated material so greatly in-

fluences the results it is not possible at the present time to determine accurately the temperature effect. It may be the same as that given in equations for computing the flow of water through sand, or it may be different.

One major factor influencing the length of filter run is variations in the clogging tendency of the coagulated material in the water. It has been stated that there is no way at present of even approaching the clogging tendency of the coagulated material by computation. Some tests have been made in an effort to establish the length of filter run which might be expected with a given size of sand and a given amount of coagulated material when no other material is present to influence the strength of the coagulated matter. The results have not been as uniform as one should expect, and it is impossible to state the exact value. When 10 p.p.m. of aluminum sulfate is added to water (free from suspended matter), is coagulated and then filtered without settling out any of the coagulated material, the filter runs are somewhere between 40 and 80 hours for sand of 0.5 mm. effective size. The indications are that the figure is near the higher value. Without varying the amount of aluminum sulfate, the runs may be as low as one hour for some waters when microörganisms are abundant.

With no means of computing the clogging tendency of the suspended material it does not seem worth while to give a great deal of time to other factors which produce but minor influences. If it is ever found possible to accurately estimate the clogging tendency of coagulated matter, then it will be possible to develop a theoretical equation for computing filter performance which will be accurate enough for practical uses. The writer is of the opinion, however, that development of an equation for computing the clogging tendency of coagulated material is going to be an extremely difficult task, and that at present we should try to use as advantageously as possible empirical data based upon actual filter performance. This statement is not made for the purpose of discouraging attempts to find a means of computing the clogging tendency of coagulated material, but to state that it should be the first step in the development of a theoretical equation for computing a predicted filter performance. If this cannot be done there is certainly little need of determining the minor factors.

Effect of the Rate of Filtration.—It is desirable to give consideration to filtration rates other than the customary rating of 2 gallons per square foot per minute, because very few filtration plants are operated continuously at exactly this rate. Our experiments on filters operated at various rates over long periods of time show that the filter runs vary approximately as the 1.5 power of the rate in gallons per square foot per minute. This may be expressed by the equation

$$H = \frac{K}{B^{1.5}} \qquad (3)$$

K is a constant which will vary with the clogging tendency of the water.

B is the rate of filtration in gallons per square foot per minute.

H is the filter run in hours.

When the effect of the rate of filtration is taken into consideration, equation 1 becomes

$$H = \frac{K\,D^{2.15}}{B^{1.5}} \qquad (4)$$

It is believed that the effect of filtration rate also can be taken into consideration in equation 2 by adding its effect to the equation. The equation then will be

$$H_1 = \frac{K\,(D_1^{2.15})\,(P_1^{2.13})}{(P^{2.13})\,(B^{1.5})} \qquad (5)$$

The value of K in equations 4 and 5 will not be the same as for equations 1 and 2, but it is still a constant. If K is determined for the 2 gallon rate in equation 2, and it is desirable to use some other rate of filtration, the value of K in equations 4 and 5 will be 2.83 times its value in equation 2. So long as the filter runs with some certain size of sand and the condition of water, porosity of filtering material, and rate of filtration are known, the runs for any other size of sand, rate of filtration and porosity of filtering material may be computed.

Equations May Not Be Exact.—Equations 1 to 5 have been determined from a large number of tests on the Lake Michigan water. They are based upon empirical data and it may be found that slight modifications will need to be made to make them applicable to other waters. For the particular water upon which the tests were made, the results check very closely. Where great accuracy is desired, those using the equations should test their accuracy on the particular water to be dealt with. It is believed that only minor modifications will be found necessary and that the modifications will be confined to varying the powers of the factors used. The effect of size may be slightly different from the 2.15 power of the diameter, the effect of porosity may be slightly different from the 2.13 power of the percentage porosity, and the effect of the rate of filtration may be slightly different from the 1.5 power of the filtration rate. Information from other sources will be required to determine if changes are necessary. It also may be well to again state that these equations are based upon fairly clean filter beds, where cracks do not form, and where the beds do not pull away from the side walls of the filters. Where these conditions occur the runs probably will differ from those obtained on a clean bed. The number and size of cracks vary widely in filter beds, and the depth to which filter beds pull away from the side walls also varies widely. It is evident that no definite value can be assigned to these factors.

Experimental Results

Following the procedure used in Part 2, no attempt will be made to give detail figures of the experiments, for it would require entirely too much space for one article. In practically all of the experiments, figures are available for periods ranging from a few months to a year or more.

Sizes of Materials Used.—Table 5 shows sievings of most of the materials used in the experiments on various kinds of filtering materials. For the first of the materials given in the table, an attempt was made to have the materials fairly uniform, with a uniformity of size about the same as that of sands in common use for filtration work. Even though the materials in some instances were sieved and the sieved portions combined in about the proper ratio, it was found later from sievings of the beds and using the new method of determining the effective size that the beds were not quite as uniform in size as it was hoped they would be. It was intended to have some of the beds vary widely in size and grading.

Effect of the Kind of Filtering Material on the Lengths of Filter Runs.—Table 6 shows the filter runs for several kinds of filtering materials. It will be noted that the actual filter runs on beds of crushed quartz and

TABLE 6.—EFFECT OF THE KIND OF MATERIAL ON THE LENGTHS OF FILTER BEDS.

Filter	JX-3	DX-2	EX-3	HX-3	Z-4	FX-4
Material	Ottawa Sand	Muscatine Sand	Crushed Quartz	Anthracite Coal	Crushed Glass*	Minchar
Effective size mm.....	.503	.489	.475	.450	.540*	.519
Uniformity coefficient..	54	28	28	18	12	52
Porosity	41.6	42.1	52.9	50.3	55.2	64.8
Hours filter runs.....	15.8	15.8	23.3	18.2	43.1	61.5
Computed runs, using Ottawa sand as basis	15.8	15.3	23 3	18.6	33.6	43.4

*Due to flat pieces of glass accumulating at the surface, it is not possible to get the real effective size from a sieve analysis. This size was obtained from sieving the top ½ inch of material. Microscopical examination indicates the size should be between .60 and .70 mm. (See Table 7.)

anthracite coal are close to the computed runs using Equation 2. As the Ottawa sand was used to determine the clogging constant K, the computed runs on this material are the same as the actual runs.

The computed results in Table 6 for crushed glass and Minchar do not coincide closely with the actual runs. It has been stated that the glass in this bed contained a number of flat pieces. Many of these flat pieces came to the top of the bed after it was washed. The sieving test on the top one-half inch of the bed indicated an effective size of 0.540 mm. There is not much information on the characteristics of flat materials and how best to determine the effective size. Measurement of the longest diameter and the two other diameters at right angles to this diameter and to each other are given in Table 7 for a number of the grains taken from the top of the bed. It will be noted that the middle diameter is considerably longer than that of the shortest diameter for many of the particles, showing that they were thin, flat particles. It is probable that the real effective size of the material near the surface of the bed was greater than 0.540 mm. diameter and that the porosity of this material was greater than 55.2 per cent. The porosity as shown was determined on a representative sample of the entire bed.

The crushed glass used in Filter EX-2 was somewhat different from that used in Filter Z-4 in that it was of very non-uniform grading and some of the top material was washed away before it was used in the tests under consideration, consequently it had very few flat particles. It will be noted from Table 8 that the actual filter runs on this material coincide closely with the computed runs. The effect of the depth of the bed on the effective size was determined in the manner described in Part 2.

TABLE 7.—SIZE AND SHAPE OF CRUSHED GLASS AT THE SURFACE OF FILTER Z-4 AFTER WASHING.

(Measurements made with the Microscope.)

Longest Diameter mm.	Middle Diameter mm.	Shortest Diameter mm.
.97	.91	.25
.78	.70	.25
.95	.83	.40
.90	.80	.22
1.20	.67	.35
1.12	.70	.30
1.00	.70	.35
1.15	.80	.30
1.45	.95	.30
.72	.55	.60
1.10	.57	.35
1.15	.70	.25
1.55	.68	.20
.99	.66	.25
1.62	.57	.25
1.05	.67	.20
.95	.73	.10
.90	.73	.30
1.08	.70	.30
1.35	.65	.33
1.00	.77	.42
1.05	.70	.20
1.35	.54	.40
1.12	.78	.40
1.03	.68	.30
1.25	.95	.20
.90	.83	.20
.85	.40	.28
.90	.83	.25
1.20	.66	.35
1.12	.65	.38
1 10	.70	.35
.98	.70	.30
1.70	.76	.40
1.18	.90	.45
.95	.72	.18
1.05	.67	.25
.88	.72	.38
1.10	.67	.30
1.05	.70	.30
Aver. 1.119	.715	.304

TABLE 8.—COMPARISON OF LENGTHS OF FILTER RUNS ON SAND AND CRUSHED GLASS.

(Filter run for a period of 2.3 months.)

Filter	DX-1	EX-2
Material	Muscatine Sand	Crushed Glass
Depth of bed.....	24 inches	16 inches
Effective size, mm.	.444	.515
Uniformity coefficient	10.8	5.6
Porosity	42.1	*55.2
Average filter runs in hours.....	9.9	25.0
Computed runs using Muscatine sand as basis.....	9.9	24.2

*Porosity not determined on this sample. The figure used is taken from the porosity of another sample of crushed glass. It is believed, however, that 55.2 per cent is close to the actual porosity of this material.

The computed runs for the Minchar, as shown in Table 6, are less than the actual runs. Again it is difficult to determine the real effective size of the material at the surface. It is probable that there were a few very irregular shaped grains washed to the surface which materially increased the porosity of the top material over that of the entire bed. In fact the porosity as determined may not be accurate. It is believed that the granules themselves were porous and that the actual porosity between the granules was slightly less than the porosity as given, which was determined from the dry material on a representative sample of the entire bed. It also is believed that the porosity of the top material after washing was in excess of that shown, due to very irregular shaped granules washing to the top. In removing the top two inches for a sieve analysis, it was found that the weight was considerably less than that of the next two inches of the bed.

It is not discouraging to find that the runs on one filter using crushed glass, and the runs on the Minchar filter are longer than the computed runs. There are very good reasons to explain why they are longer. These are exceptional cases, and if such materials should be used to any extent in filtration, some more refined method of determining the size and porosity of the top material should be used.

Comparison of Muscatine Sand and Anthracite Coal.—Table 9 shows comparison of sand obtained from Muscatine, Iowa, and Anthracite coal obtained from the filter plant at Denver, Colorado. Tests on these two materials were run over a period of one year. Using Muscatine sand for computing the constant K in equation 2, the actual and computed runs on the Anthracite coal are

TABLE 9.—COMPARISON OF LENGTHS OF FILTER RUNS ON SAND AND ANTHRACITE COAL.

(Filters run for a period of one year.)

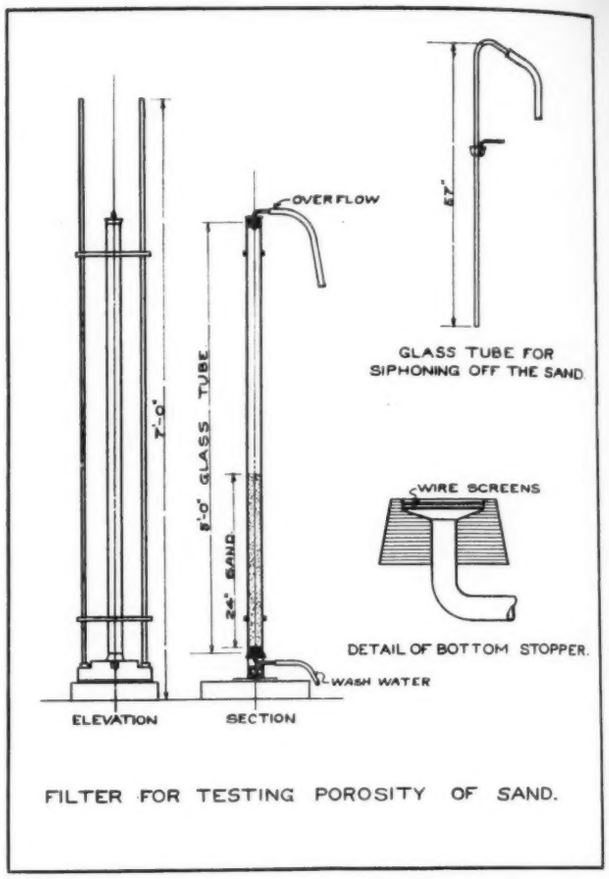
Filter	D-1	J-3
Material	Muscatine Sand	Anthracite Coal
Depth of filter bed	24 inches	24 inches
Effective size, mm.	.444	.617
Uniformity coefficient	10.8	(?)
Porosity	42.1	50.9
Average filter runs in hours	22.9	69.4
Computed runs, using Muscatine sand as basis	22.9	69.6

almost exactly the same. This is closer than should be expected, but it gives proof that the equation is fairly dependable. A small amount of fine sand happened to get mixed with the coal in the filter and this stayed largely in the lower few inches of the bed, though there was some fine sand which extended up perhaps 12 inches from the gravel. It was necessary in this case to determine the effective size of the material by taking a sample from the top 6 inches of the bed. The method of determining the effective size on samples collected from the top of the bed was described in Part 2. The fine sand did not affect the size of the coal when sampled in this manner, but when a sieving was made of a representative sample of the entire bed, it materially affected the results. This illustrates the importance of having a method of determining the effective size by collecting the sample from the top 6 inches of the bed.

Experimental Results Coincide Very Closely with Computed Results.—It has been shown from experiments that the lengths of filter runs on one material as compared with those of some other material follow the equation very closely. The results may not be so close for other waters, though it is believed the equation will give results which are close enough for practical purposes. As stated, it may be necessary to change the powers of some of the factors slightly when data are available from other sources.

With the wide variations in size, grading and kind of materials, it seems that the equation must have some merit when it gives results so close to the actual figures. In the case of filter EX-2 it will be noted from Table 5 that the grading was very irregular and the depth of the bed was less than 24 inches, yet the computed runs were very close to the actual runs. This indicates that the method of taking the depth of the bed into consideration in determining the effective size as described in Part 2 also gives fairly accurate results. It is evident that it would not be possible to establish such close relation between actual and computed results without a method of determining the real effective size of material for rapid sand filter beds. The Hazen effective size might hold fairly well if all filtering materials were of the same uniformity, but as they are not, the writer does not see any advantage in retaining the 10 per cent size as the effective size of filter sand when it is known that its accuracy extends over a very limited range in the grading of filtering materials.

Determining the Porosity of Filtering Materials.—It is essential that the porosity of filtering materials be determined in a manner that will give the same porosity as that in filter beds. Hulbert and Feben (*Water Works Engineering,* January 10, 1934) developed a method of determining the porosity of filtering materials by use of the long glass tube of the Jackson Candle Turbidimeter. A certain weight (150 grams) of the material is added to the tube half full of water. The



Filter for Testing Porosity of Filter Beds—Developed and Used in the Chicago Experimental Plant.

tube is completely filled with water and a stopper is inserted so that there will be little or no air space. The tube is inverted and held until all of the material settles. It is then rotated 180 degrees to an upright position and held as near as possible in a vertical position. The material dropping to the lower part of the tube stratifies itself somewhat in the manner that it does in a filter bed, and it settles to a porosity not far from that of filter beds. The writer is of the opinion that the results are not quite accurate enough for use in equations which take into consideration the porosity of the material.

Our procedure of determining the porosity is to take a glass tube filter and suspend the filtering material by washing the filter. The wash water is cut off gradually so that there is a span of fully 15 seconds during the cutting off of the flow of water. This may not produce results which are exactly the same as when the wash water valve is closed on a filter, though it is believed to be so near the same that the error is very little. Details of the equipment used for determining the porosity are shown in Figure 6. A tube was selected which was uniform in diameter. It was marked off in sections and each section calibrated accurately. Weighed portions of the materials which gave a depth of approximately 24 inches in the tube were used. The specific gravity of the material had been determined previously. Knowing the specific gravity and the weight of the dry material, it was not difficult to determine the percentage of voids in the bed after washing. There can be no question about the porosity being determined accurately in this manner, and the only part of the procedure open to criticism is that the material may not settle back in the glass tube filter exactly as it will settle in a larger filter bed. This, however, should not materially affect the

TABLE 10.—MEASUREMENT OF THE SIZE OF SANDS WITH THE MICROSCOPE.

Comparison of Shape Ratio with Porosity.

February 15, 1934.

Copley, Ohio		Ottawa, Ill.		Muscatine, Iowa	
Longest Diameter	Middle Diameter	Longest Diameter	Middle Diameter	Longest Diameter	Middle Diameter
mm.	mm.	mm.	mm.	mm.	mm.
1.8	1.3	1.7	1.4	2.1	1.6
3.2	2.3	1 6	1.4	1.5	1.2
2.0	1.5	1.4	1.3	1.0	.7
2.4	1.3	1.4	.9	1.4	.9
2.9	1.4	2.5	1.2	1.4	.9
2 6	1.2	2.6	1.3	1.2	.8
3.7	1.7	2.0	1.5	2.1	1.7
1.8	1.6	1.5	1.3	1.3	1.1
2.2	1.2	1.3	1.1	1.4	1.2
3.2	1.7	1.4	.9	1.7	1.4
2.9	1.6	1.2	1.1	1.2	.7
1.4	.9	1.2	1.0	.9	.7
1.7	.9	1.4	1.2	1.8	1 2
2 7	1.7	1.4	1.3	1.4	1.2
2.2	1.5	1.6	.8	1.1	.6
1.7	1.1	1.4	1 3	1.4	1.1
1.8	1.2	1.3	.9	1.2	.9
2.2	1.4	1.3	1.2	1.0	.7
1.7	1.4	1.5	1.4	1.4	1 3
1.3	1.0	1.6	1.3	1.8	1.5
2.7	1.4	1.5	1.2	1.0	.6
2 3	.7	1.8	1.4	1.6	1.0
1.4	1.1	1.5	1.1	1.7	1.2
2.4	1.3	1.6	1.2	1.6	1.2
1.6	.8	1.7	1.2	1.3	.8
2.4	1.4	1 7	1.4	1.6	1.4
2.4	1.6	1.3	1.0	2.4	1 6
2.7	2.2	1.1	.8	1.7	1.5
2.3	1.3	1.6	1.4	2.5	1.7
2 1	1.4	1.6	1.4	1.0	.7
Aver. 2.26	1.37	1.56	1.20	1.49	1.10
*Shape Ratio	1.65		1.30		1.355
Porosity	52.9		41.6		42.1
Porosity ÷ by Shape Ratio	31.5		32.0		31.1

*Longest diameter divided by middle diameter constitutes the Shape Ratio.

equations, because the filter runs were determined on glass tube filters of similar size.

It may be possible to obtain some idea of the porosity of sand and crushed quartz by measuring the shape of the grains with a microscope. When such materials are spread out on a flat glass plate they will rest largely with the shortest diameter in a vertical position. The shortest diameter then observed with the microscope may be called the middle diameter. The relations between the middle and longest diameters and that of the porosity for three materials which were measured are shown in Table 10. It may be an accident that these relations are so close and this method of indirect porosity determination should not be used until it is tried on other samples of sand and crushed quartz. It is very likely that there is no definite relation between the porosity and shape of all kinds of materials measured in this manner, but if it proves fairly accurate for sand and crushed quartz it will be applicable to most materials which will be used for filter beds.

Summary

1.—Experiments on various kinds of filtering materials have been conducted. Natural sands, crushed quartz, anthracite coal, iron ore, crushed glass, Minchar, and cocoanut char were used.

2.—The effect of porosity was found to vary approximately as the 2.13 power of the percentage porosity.

3.—A general equation for comparing one filtering material with another has been developed.

4.—The equation takes into consideration the size, porosity, and rate of filtration, but not the temperature and clogging tendency of the coagulated material in the water. To use the equation, the length of filter run for some certain condition must be known.

5.—Computed and actual runs are very close, except for certain conditions.

Michigan Conference on Water Purification Holds 12th Meeting

The Michigan Conference on Water Purification held its 12th Annual Meeting September 19th to 21st, at Michigan State College, East Lansing, Mich.

The conference (84 registered) opened with a discussion of plant operating problems, which included the results of tests applied to various activated carbons on the market. These tests were applied at the Highland Park (Mich.) plant in an effort to determine which carbon was the most efficient in the removal of the odors and tastes. Comparative results on the phenol absorption test; threshold odor tests; iodine absorption tests; opacity of filter paper tests; suspendability tests; and apparent density were given.

Midland reported on the use of home-made carbonation equipment using both coke and Diesel engine exhaust as a source of the gas.

J. M. Potter, of the Pennsylvania Salt Company, discussed the safe handling of chlorine and ammonia, illustrating the topic with lantern slides.

In the evening, John P. Harris, of Industrial Chemical Sales Co., by means of lantern slides, showed the various methods now effectively employed in feeding activated carbon. A discussion of questions submitted by those in attendance was followed by a Smoker.

Eskill Nordell, of the Permutit Company, gave an interesting illustrated talk on the mining, processing, manufacture and uses of zeolites. Then followed a description of the East Lansing Softening and Iron Removal Plant being installed as a PWA project and using an automatic zeolite system.

Members of the Detroit Water Department emphasized the necessity for proper installation and maintenance of plant equipment, both mechanical and electrical.

The effects of ammonia treatment in the production of nitrifying bacteria and the attempt to determine the specific organisms which cause an increase in the nitrites in filters were presented by Douglas Feben of the Detroit Water Department.

An interesting discussion of A. P. H. A. Standard Methods was presented by Dr. Mallmann of the Michigan State College, which resulted in the conference appointing him as chairman of a committee to study and report on the possibilities of the suggested Brilliant Green Bile Lactose Broth media for routine testing in the water works laboratory.

Due to the never ceasing importance of plankton and their odor-producing possibilities in water supplies, some considerations of plankton and plankton problems were presented by Hilary J. Deason of Ann Arbor. After discussing the various types of organisms and their production and indices of production, the factors regulating their abundance, their cycles and their effect on water supplies were discussed. Methods of collecting and the laboratory method of studying and enumerating plankton were outlined.

Officers elected for the ensuing year were: Harry T. Campion, Grand Rapids, Chairman; Irving Dahljelm, Highland Park, Vice-Chairman; John M. Hepler, Lansing, Secretary; Douglas Feben, Detroit, and Anthony Keils, Mt. Clemens, Members Executive Committee.

A STIRRING APPARATUS FOR THE DETERMINATION OF COAGULANT DOSAGES*

By THOMAS M. RIDDICK

Dept. Sanitary Engineering,
New York University, New York City.

THE optimum coagulant dosage is usually determined by experience or after visually observing floc formation in coagulating basin. Should the source of water supply be a large lake or reservoir where the quality of water varies only seasonally, such a procedure may yield satisfactory results, but when the quality varies from day to day, as in the case of many of our smaller streams, there is need of a more effective an exact control of applied coagulants if economy is to be effected.

It has been found by experience that in practical floc formation there is usually an optimum dosage—a best dosage—which is superior to a higher or lower dosage. That is to say, as good or better floc may be formed at 20 than at 30 p.p.m. coagulant dosage.

It has also been determined that the addition of small amounts of lime or soda ash may greatly improve flocculation even though there exists enough natural alkalinity to combine with the coagulant.

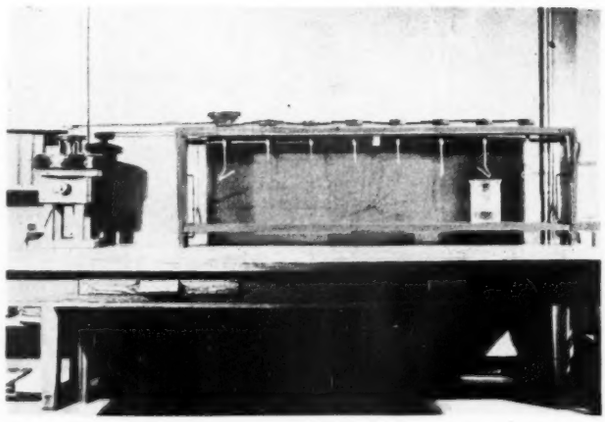
Cut and Dry Procedure.

Obviously the most satisfactory means of coagulant control are empirical, and for the collection of such data a stirring laboratory apparatus is necessary which will insure a uniformity of agitation in each of several beakers or jars when making the flocculating test. All conditions should be the same with but one variable, viz.: the dosage of coagulant or alkali added to the water samples.

It is impossible to accurately reproduce the conditions of mixing effected by a baffled or mechanical mixing basin, but if coagulants are to be studied on a laboratory scale, the jar test is the most satisfactory means. When battery jars are used as containers and stirring is accomplished manually by use of a glass stirring rod, considerable discrepancy will occur due to non-uniformity of agitation and time of stirring. If as many as six or eight jars are used in this test, the time required for its performance is prohibitive, uniformity impossible. The stirring apparatus, here pictured, eliminates these two difficulties.

The Home Constructed Stirrer.

A ceiling fan motor was used on account of its slow speed as well as the fact that it was already available. It was mounted upside down by simply reversing the bearings. It will be noted that the accompanying drawing

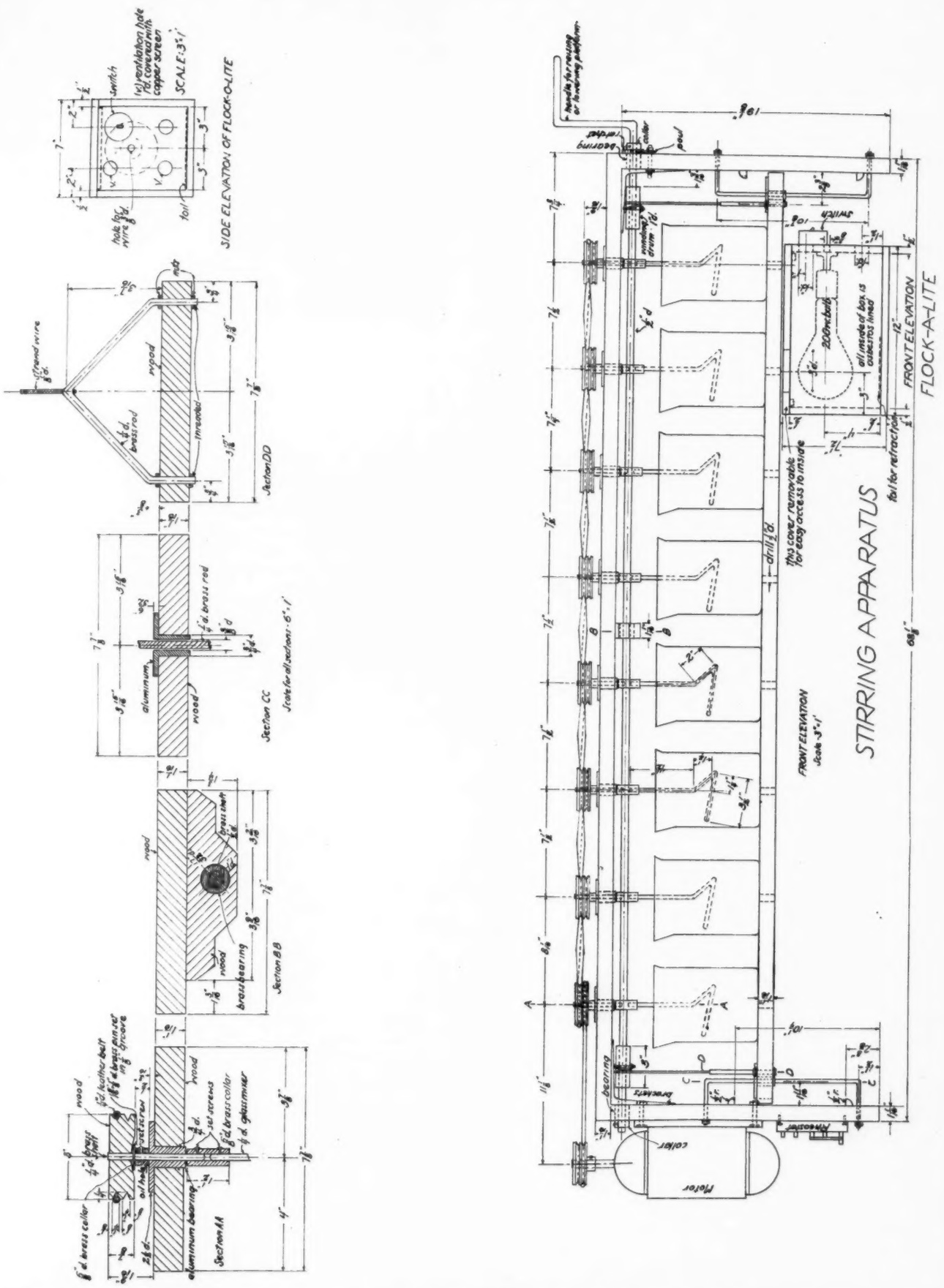


Laboratory Stirring Apparatus for Making Flocculation Tests. The Handle for Raising the Lower Shelf Is Barely Visible in the Right End.

shows a different type of motor (with rheostat) which would be more advantageous if the motor must be purchased new. Two sizes of drive pulleys were provided to give variations in the speed of the driving motor. The apparatus consists of eight separate stirrers, on the first shafting of which is fastened a series of four drive pulleys of graduated sizes. By means of these four pulleys, plus the two sizes of drive pulleys, the speed of stirring may be varied in eight equal increments from 100 to 400 r.p.m. Stirring rods were made by bending solid glass tubing and may be constructed to any desired shape. The shelf for supporting the 2 liter beakers has concentric circles etched into the wood with each center directly under a stirrer. This facilitates the accurate placement of any size of beaker. The shelf may be easily raised or lowered by means of a crank at the end, so that beakers may be put in place without removing the stirring rods. After raising, the shelf is held in place by a ratchet and pawl. It has been found that following a rapid mix the lower speeds are better for floc formations since there is no tendency to break down the particles once formed, into a fine pin floc.

Upon observation of the floc formed by a series of, say, 10 to 40 p.p.m. alum dosages it is found that there is generally an optimum dosage—and always a minimum dosage—which will give a satisfactory floc. If the turbidity of these flocculated samples is measured no correlation will be found between turbidity and floc because one may be coarse and heavy and another fine

*The second of a series of short articles by Mr. Reddick describing home-constructed laboratory equipment. The first, describing "The 20 Degree Incubator" appeared in the May, 1934, issue.—Editor.



Detail Sketch of the Home-Constructed Laboratory Stirring Machines Used in New York University Laboratories.

and light. Floc formation must be evaluated on a relative basis therefore as poor, fair, good, excellent, etc., in accord with its definition, settleability and brilliancy of the water between the floc particles. To assist in this valuation proper illumination is essential.

A half inch hole is bored through the jar supporting shelf at the center of each beaker position. Underneath it is placed the "Floc-A-Lite" which consists of a 200-watt bulb mounted in an asbestos lined box with a circular opening on top for projecting a beam of light upwards. For determining by comparison the relative density and size of floc formed, the light is successively slid underneath from beaker to beaker. Floc particles stand out boldly and the effect is similar to that of the Tyndal beam.

In summarizing the advantages, it may be said that the flocculating jar-test is of material value, and especially where alkalinity must be added for best results. The apparatus described gives absolute uniformity of mixing to each of the eight 2 liter samples, and the adjustable speeds permit a ready change from rapid to slow agitation in order to more nearly stimulate particular plant operating conditions. The ease of placing or extracting beakers (a feature of the movable shelf) reduces the time required for making the tests to such an extent that they may be made a matter of routine. Further, the lift shelf is a safety device against breakage.

This apparatus has also been utilized to good advantage in the preparation of reagents, particularly those which required considerable stirring for solution. It has also been used effectively for determining the phenol adsorption of activated carbon as suggested by Baylis in past issues of this magazine.

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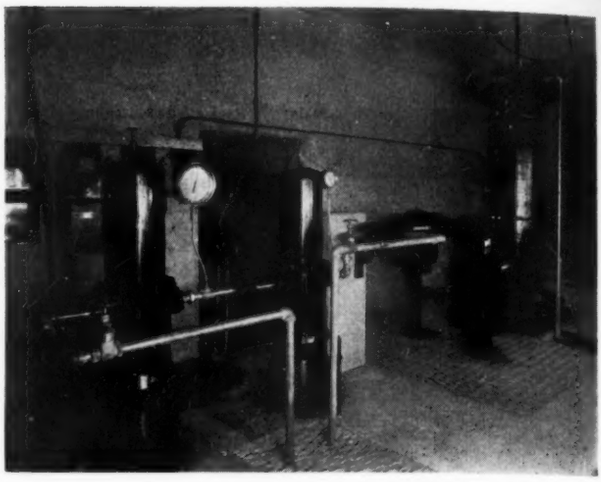
Unique Pump Installation at Morris Dam, Pasadena, California

Pine Canyon Dam, designed and constructed under the direction and supervision of S. B. Morris, Chief Engineer, and Manager of Pasadena's Water Department, was renamed the Morris Dam, by Pasadena officials upon its successful completion, in his honor. (See WATER WORKS AND SEWERAGE, July, 1934, for a description of the dam and an account of dedication exercises presided over by ex-President Herbert Hoover.)

Many new features in design and construction of concrete dams and appurtenances were developed in building the Morris Dam. The careful control of cement used, by specifications rigidly limiting heat production in setting of the concrete; methods of testing large specimen concrete blocks for strength, by special machines; application of special vibrators in pouring of the concrete; check for earthquake shocks; and the automatic control of the spillway, were among such developments.

Another novel operating feature is found in the pioneer use of centrifugal pumps, of special design, to supply high pressure water for operating the gigantic hydraulic gate valves. For this important duty, the same type of high pressure pumps were used as were developed for forcing water up the walls of the Grand Canyon, a height of approximately 3,500 ft. against 1,500 lbs. pressure, at a single boost by two 17-stage centrifugal units connected in series—efficiencies of 63.5 per cent and 66.2 per cent being realized.

At Morris Dam the automatically operated hydraulic valves are controlled from a small reservoir located 750 ft. above the dam. To this reservoir water is lifted by two Byron-Jackson "Hydropress" Centrifugal Pumps (driven by 15 hp. motors), which deliver 75 g.p.m. against the head of 400 ft. In addition, two "Hydropress" pumps are installed in the dam-tunnel. These operate in series to deliver 75 g.p.m. against a head of 800 ft., for direct operation of the gates should the line from the reservoir fail from some cause. All four pumps are identical in design and capacities and thereby are interchangeable.



High Pressure Hydropress Pump, Operating Hydraulic Valves at Morris Dam, Pasadena, Calif. One of These Valves Is Seen on the Right.

The accompanying illustration of the tunnel station at the dam pictures two of the Byron-Jackson Hydropress Pumps in operation during a test. The first unit builds the pressure to 270 lbs. and the second about doubles it to 530 lbs., which is sufficient to supply the high reservoir or to operate the hydraulic valves direct and immediately in case of necessity. Normally the other station operates to supply the high reservoir, providing full automatic control of the outlet valves located in the novel gate-house of "caterpillar" design.

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Association Meetings Scheduled

Oct. 15—**New England Sewage Works Association.** Hotel Biltmore, Providence, R. I. Secretary, F. W. Gilcreas, State Department Health, Albany, N. Y.

Oct. 15-16—**Missouri Water and Sewerage Conference.** Hotel Drake, Carthage, Mo., Secretary-Treasurer, Herbert M. Bosch, State Department of Health, Jefferson City, Mo.

Oct. 15-17—**International City Managers Association.** St. Louis, Mo. Executive Director, C. E. Ridley, 850 East 58th Street, Chicago, Illinois.

Oct. 15-18—Southwest Waterworks Association. Hotel Hilton, Waco, Texas. Secretary, Lewis A. Quigley, Superintendent Water Department, Fort Worth, Texas.

Oct. 24-27—**California Section, A. W. W. A.** Long Beach, Calif. Secretary, J. E. Phillips, Department Water Supply, 207 Broadway, Los Angeles, Calif.

Oct. 29-31—**Pennsylvania Water Works Association.** Haddon Hall, Atlantic City, N. Y. Secretary, F. H. Snow, 507 Telegraph Bldg., Harrisburg, Pa.

Nov. 12-14—**North Carolina Section, A. W. W. A. and North Carolina Sewage Works Association.** Hotel Virginia Dare, Elizabeth City, N. C. Acting Secretary-Treasurer, M. F. Trice, State Department of Health, Raleigh, N. C.

Nov. 8-10—**Missouri Valley Section, A. W. W. A.**. Hotel Fontenelle, Omaha, Neb. Secretary, Prof. E. L. Waterman, University of Iowa, Iowa City, Iowa.

Jan. 16-18—**American Society Civil Engineers.** New York City. Secretary, Geo. T. Seabury, 33 West 39th Street, New York City.

EDITORIALS

Self-Supporting Utilities

THE ambition of every progressive manager, superintendent or engineer having charge of municipally operated water works, is to put the operation of this utility on a self-supporting, if not a profit-making basis.

Public Service Commissions and Courts before which utility matters of a regulatory nature are brought are more and more plainly taking the attitude that the operation of the local water works should primarily be classified as a business enterprise and only secondarily as a function of local government. These are healthy signs and the extension of this attitude on the part of Public Service Commissions will prove beneficial to the municipal water works and relieve political pressure on superintendents and commissioners of water works who realize that business and politics are not, and never were, a safe mixture.

Water Departments, to be operated for the greatest benefit of consumers and property owners, must be freed to the fullest extent from a type of management which may be molded to suit some political expediency. One of the most telling arguments presented by economists, who have come forward with opinions that construction and betterments of public works can not be relied upon as a sound and positive means of breaking economic depressions is: that, under past and present methods of political management of municipal utilities and public-works generally there can be no sound planning set up sufficiently in advance to make it practical to depend on municipal construction as a dependable economic program to defeat depressions. They cite the general lack of sound financing and the paucity of prior planning as the reason for the failure of P.W.A. efforts to accomplish its intent in the recent crisis, without serious and disappointing delays.

All of this points to the need for divorcement of municipal utility operations and management from the political end of local government. Where that has been accomplished sound financing and advance planning has been the rule and not the exception. Some of the best conditions found have been those in communities served by Water Commissions which have been in charge of the utility since the time that it was taken over from a private corporation by the municipality. Fortunately, such Commissions have by statute or otherwise been spared political interference and having, in numerous instances, inherited well managed properties have generally strengthened the utility.

Many managers of municipally operated water works have contended that if there be surplus earnings from the operation of this utility, these should not be used for any purpose other than for water works betterments. Be that argument sound or otherwise, there has been a decided trend toward the transfer of Water Department profits to the general municipal fund for use in taxation relief. Whether we like it or not, certain important State Supreme Courts have ruled that such use of utility earnings is legal so long as the financial and physical condition of the water utility is not jeopardized. Furthermore, opinions have been rendered, stating that rates may be increased sufficiently to yield profits to be devoted to financing other municipal enterprises. In other cases property owning taxpayers have been awakened to the fact that the local Water Department had been too largely financed out of the general tax fund—plainly a political expedient. The result has been a demand to increase water rates to reduce the burden on tax paying property owners.

We cannot deny the fact that economists, who have put municipal "business" under the microscope, have at least some grounds for their opinions as to the lack of reliability and soundness of utility and public works management under existing political systems. The pity of it is that municipally operated utilities could not have been forced into codification along with privately operated utilities. It would have served as a foundation for structures which might later be subjected to scrutiny, without fears of criticism by the nation's economists and Public Service regulatory bodies.

Since the trend of the times is definitely in the direction of considering the water utility a private business, it remains to be seen how far Public Service Commissions will be empowered to extend their regulations to municipally operated utilities. For the benefit of all, such utilities might well be placed under control and management of a local commission composed of two public spirited business men and an engineer. The selection of managers and superintendents and the fixing of salary (plus a bonus on earnings) and tenure of position should be placed in their hands; and, further, the entire water utility functions be removed from political interference and appointments.

A directorate might be established to prescribe water rates and to declare reasonable "dividends" to be paid into the general tax fund of the community whenever expedient and safe. In this way the water utility could be made as much more than self-supporting as local expediency demands and the owners of the utility—taxpayers—would receive such dividends indirectly in the form of lower taxes. In such a case non-taxpaying consumers would in reality be contributing to lighten the burden of taxpayers, but after all the general community interest is a matter of greater concern.

Fortunate would be the municipality which, having bought its privately operated utilities, henceforth received the dividend checks which in the past had been leaving the community without benefit to taxpayer or consumer.

If this statement seems socialistic in its conceptions it is well to remember that the time has not come when a public service utility can be logically nor happily divorced from participation by the community it serves. Logically, if not necessarily, it will always be a partnership enterprise and a monopoly which the public must, for the sake of self interest, participate in—support or condemn.

Is there any hope that sewage treatment can be made self-supporting? Grand Rapids, Mich., Dalton, O., Springfield, Ill., and other cities have made notable progress in this direction, and Herington, Kansas (as recounted in the feature article of this issue) has gone practically the whole way. By good fortune it has a purchaser of the whole of the effluent of its treatment works for industrial use, thereby becoming the first city to boast a self-supporting sewage treatment works.

NEW EQUIPMENT AND LITERATURE

"Triple-A" Aluminum Paint*

Quigley Company, Inc., manufacturers of the famous "A. A. A." Protective Coatings, have issued a brochure setting forth distinctive features of Triple "A" No. 44 Aluminum Paint, which does three things at one operation. Its bituminous base, serving as the vehicle for the flaked aluminum, primes and protects the surface on which applied. The aluminum, in "leafing out" to the surface after application, serves as the beautifying coat—i. e., two coats are applied at each stroke. The aluminum "floats" downward when painting ceilings or the underside of structural members.

Another interesting feature claimed in the Quigley bulletin is its adaptability for application to damp surfaces—"it displaces the moisture, seals the surface." One of the most important features is its ability to penetrate under rivet heads and into seams; and, as a water proofing coating the bituminous vehicle is reported to be 98 per cent efficient (by government test) when containing aluminum powder.

For this well prepared (beautified) bulletin, address—Quigley Co., 56 West 45th Street, New York City. Copies are available also at this office. Ask for "Two Coats with One Stroke."

*1 gal. No. 44 Vehicle + 2 lbs. Alcoa Albron (flaked aluminum) produces 1⅛ gals. of paint.

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Roots-Connersville Centrifugal Blowers

Roots-Connersville Corporation of Connersville, Ind., a firm with 80 years' experience in building blowers of the Rotary Positive type, now offers Centrifugal Blowers in addition.

Roots-Connersville Centrifugal Blowers (Type "OI") have the following features of interest. Impellers are mounted directly upon the extended shaft from the motor or turbine. In type "OIB" blowers each unit has its own shaft and bearings, adapting these to coupled, geared or belted drives for heavy duty service. Type "A" machines have a double inlet arrangement which the manufacturer claims to be just as important in handling gas or air as in the handling of liquids. All types have a throttle (damper) valve in the inlet, to regulate the air volume.

Casings are normally supplied in Cast Iron and standard impellers are of aluminum alloy, but other materials are available if desired. Standard "OI" Type Blowers are available in capacities of from 100 to 8000 cu. ft. of free air per minute at 3,500 r.p.m. against 3 lbs. pressure. Other types (multi-stage blowers) have higher capacities against higher heads.

For a copy of the new bulletin—"Centrifugal Blowers"—address Roots-Connersville Blower Corporation, Connersville, Ind.

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Chain Belt Company of Milwaukee have just issued an interestingly illustrated pamphlet describing Rex speed prime pumps which are especially adapted to well-point and other difficult dewatering operations in construction and operation. Distinctive features illustrated include: the rapid self-priming mechanism; great air handling capacity; open impeller design to pass large objects, blocks of wood, etc.; the Rex clean-out valve, exclusive to Rex pumps; recirculation cut-off valve, insuring full capacity operation and no loss motion from leakage back to the suction line.

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For the bulletin—"Rex Speed-Prime Pumps"—address Chain Belt Co., Milwaukee, Wis.

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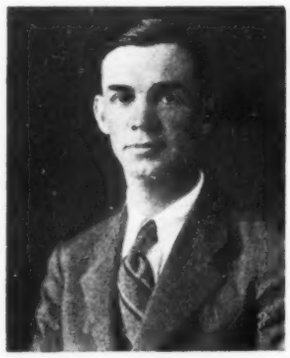
J. M. Potter Joins Pennsylvania Salt Manufacturing Company

J. M. (Jim) Potter, for the past 3½ years Superintendent of Filtration at Hertford, N. C., has recently become affiliated with the Pennsylvania Salt Manufacturing Company as assistant to L. L. Hedgepeth, Manager of Technical Service.

Mr. Potter, a North Carolinian, is a graduate engineer (1926) of North Carolina State College. Having been connected with Wm. C. Olsen, prominent consulting engineer of Raleigh, N. C., for 4 years in water works and sewerage projects and thereafter serving as Assistant Engineer of the N. C. Department of Health, before taking charge of the Hertford plant, Mr. Potter comes to Pennsylvania Salt Company well grounded for technical service work in the sanitation field.

Pennsylvania Salt Manufacturing Company supply a complete line of chemicals employed in filtration, softening and sterilization of water and for sewage treatment. Mr. Potter's services will be at the disposal of users and prospective users of such products. His headquarters will be at the company's principal offices, Widener Building, Philadelphia.



J. M. Potter

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of March 3, 1933,

Of Water Works and Sewerage, published monthly at Chicago, Illinois, for October 1, 1934.

State of Illinois, County of Cook, ss.

Before me, a notary public in and for the State and county aforesaid, personally appeared E. S. Gillette, who, having been duly sworn according to law, deposes and says that he is the Business Manager of Water Works and Sewerage and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

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Managing Editor—C. T. Murray, 400 W. Madison St., Chicago, Illinois.

Business Manager—E. S. Gillette, 400 W. Madison St., Chicago, Illinois.

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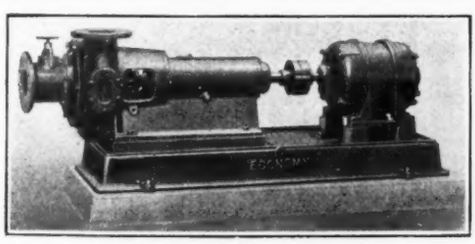

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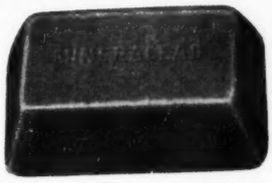

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CIVIL ENGINEER—Age 44; married; 15 years' experience as designer on large sewage treatment works and collecting sewers; 7 years' surveying experience on highways and sewers. Address: No. 2122, Phila. Technical Service Com., 1317 Spruce Street, Phila., Pa.

CIVIL ENGINEER—B.C.E. Polytechnic Institute of Brooklyn '34, age 22, single. Desires work of any nature qualified for. Location immaterial. Available immediately. Address "I. A.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

SANITARY ENGINEER—B. S. in Civil Engineering with Sanitary Engineering option. N. Y. U., '34; age 21. Desires work in the sanitary field. Location immaterial. Available immediately. Address W. M. S., % Water Works and Sewerage, 420 Lexington Ave., N. Y. C.

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CIVIL ENGINEER — Age 43; married; graduate; experienced in design of large and small sanitary and storm-water sewers; flood prevention structures, investigations and reports, highway construction of all types. Address: No. 2017, Phila. Technical Service Com., 1317 Spruce Street, Phila., Pa.

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